Kean Univeristy
Union, NJ

AE 482 FINAL REPORT

NEW JERSEY CENTER FOR SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION BUILDING

John P. Mulhern
Houser/Dannerth
April 14, 2009

Kean Univeristy
Union, NJ

EXECUTIVE SUMMARY

The NJCSTME Building is a 6 story educational building for Kean University in Union, NJ. There are many classrooms and labs for education. The building embraces the irregular layout and form of modern architecture. It contains a 280 seat auditorium, exhibition space, and even a 3D Cave. The new building reflects the advancement of modern technology in our age.

"AE 482 Final Report" is the final report for the AE Thesis Program in the Spring semester 2009. This report documents four new lighting designs for the lobby, auditorium, a classroom, and the outdoor area adjacent to the south façade. This building is a symbol of the advancement of technology which Kean Univeristy is a part of. The lighting design should be a symbol of this as well. The lighting design will reflect a computer chip which still continues to make the impossible , reality. The linear lines of light and clean, flat ceilings reflect this vital part of the advancement of knowledge.

This report is a partial redesign of the electrical system of the New Jersey Center For Science, Technology, and Mathematics Education (NJCSTME) Building. The lighting four new lighting designs required resizing for the spaces' respective panels and changes in the lighting controls. Part II is the credits section

Part III contains background information about the NJCFSTME Building. Parts IV through V contain the lighting redesign and electrical redesign of each respective space. Parts VI discusses breadth studies in HVAC and structural design concerning the increase in roof height of the auditorium space.

Part E is a cost estimate for the savings by switching from copper feeders to aluminum. Both the aluminum and copper feeder schedules are shown as a reference. Part F contains a short circuit, arc fault, and coordination study generated from a program called SKM. Finally, Part G is a short circuit hand calculation of a run from the main transformer to a branch panel. Three breakers were chosen for the interrupting rating needed and their trip curves were coordinated.

CREDITS

Thank you to the AE Department for helping, guiding, and inspiring me to make this program proud in the real world, especially…..

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Thanks to Cannon Design, Inc. for giving me the chance to work for their prestigious firm and making me feel at home especially….

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Thanks to Kean University for allowing me to write my thesis on their building.

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TABLE OF CONTENTS

I. ABSTRACT……………………………………….5
II. BACKGROUND INFORMATION……….6-8
III. DESIGN CONCEPT…………………………..9
IV. LIGHTING DEPTH
A) DESIGN CONCEPT
B) CLASSROOM REDESIGN
10-12………..EXISTING SPACE CONDITIONS
13-14………..LIGHTING DESIGN CRITERIA
15-17………..PLANS
18……………..DESIGN EXPLANATION
19……………..LUMINAIRE SCHEDULE
20………………LIGHTING RCP
21-22……….CALCULATIONS
23-28……….CLASSROOM SCENE RESULTS
29-32……….PROJECTOR SCENE RESULTS

B) LOWER LOBBY REDESIGN
33-36……….EXISTING SPACE CONDITIONS
37-41……….PLANS
42-43……….LIGHTING DESIGN CRITERIA
44……………..DESIGN EXPLANATION
45-46……….LUMINAIRE SCHEDULE
47……………..LIGHTING RCP
48-50……….CALCULATIONS
51-54……….LOBBY SCENE RESULTS
55-58……….GALA SCENE RESULTS

C) OUTDOOR SPACE REDESIGN
59…………….EXISTING SPACE CONDITIONS
60-61……….LIGHTING DESIGN CRITERIA
62…………….PLANS
63…………….DESIGN EXPLANATION
64……………LUMINAIRE SCHEDULE
65……………LIGHTING PLAN

TABLE OF CONTENTS(CONT'D)

IV. LIGHTING DEPTH (CONT'D)

C) OUTDOOR SPACE REDESIGN (CONT'D)

66-68...........CALCULATIONS
69-70...........RESULTS

D) AUDITORIUM REDESIGN

71-72...........EXISTING SPACE CONDITIONS
73-74...........LIGHTING DESIGN CRITERIA
75-77...........PLANS
78..................DESIGN EXPLANATION
78-80...........LUMINAIRE SCHEDULE
81.................LIGHTING RCP
82-85...........CALCULATIONS
86-88...........LECTURE MODE SCENE

V. ELECTRICAL DEPTH

A) CLASSROOM REDESIGN

89...................INTRODUCTION
90...................CRITERIA/CONTROLS
91...................LIGHTING RCP
92...................DIMMER SCHEDULE
93...................LUTRON SINGLE LINE
94...................EXISTING PANELBOARD SCHEDULE
95...................NEW PANELBOARD WORKSHEET
96...................NEW PANELBOARD LOAD CATEGORIES
97...................NEW PANELBOARD SCHEDULE
98...................FEEDER SIZING TABLE

B) LOWER LOBBY REDESIGN

99-100..............INTRODUCTION
101....................CRITERIA/CONTROLS
102....................LIGHTING RCP
103....................DIMMER SCHEDULE
104....................LUTRON SINGLE LINE
105....................EXISTING PANELBOARD SCHEDULE (2LNH1)

TABLE OF CONTENTS

V. ELECTRICAL DEPTH (CONT'D)

B) LOWER LOBBY REDESIGN (CONT'D)

106..................NEW PANELBOARD WORKSHEET (2LNH1)
107..................NEW PANELBOARD LOAD CATEGORIES (2LNH1)
108..................NEW PANELBOARD SCHEDULE (2LNH1)
109..................FEEDER SIZING TABLE (2LNH1)
110..................EXISTING PANELBOARD SCHEDULE (2LNL1)
111..................NEW PANELBOARD WORKSHEET (2LNL1)
112..................NEW PANELBOARD LOAD CATEGORIES (2LNH1)
113..................NEW PANELBOARD SCHEDULE (2LNH1)
114..................FEEDER SIZING TABLE (2LNH1)

C) OUTDOOR SPACE REDESIGN

115..................INTRODUCTION
116..................CRITERIA/CONTROLS
117..................LIGHTING RCP
118..................EXISTING PANELBOARD SCHEDULE
119.................NEW PANELBOARD WORKSHEET
120.................NEW PANELBOARD LOAD CATEGORIES
121.................NEW PANELBOARD SCHEDULE
122.................FEEDER SIZING TABLE

D) AUDITORIUM

123.................INTRODUCTION
124.................LIGHTING RCP
125.................CRITERIA/CONTROLS
126.................PANEL REDESIGN (**SEE LOBBY**)

E) ALUMINUM FEEDERS VS. COPPER FEEDERS

127.................INTRODUCTION
127.................ASSUMPTIONS
127.................CONCLUSION
128.................COPPER FEEEDER TABLE
129.................COPPER FEEDER ESTIMATE

TABLE OF CONTENTS

V. ELECTRICAL DEPTH (CONT'D)

E) ALUMINUM FEEDERS VS. COPPER FEEDERS (CONT'D)

130……………..ALUMINUM FEEEDER TABLE

131……………..ALUMINUM FEEDER ESTIMATE

F) SKM ANALYSIS

132……………..INTRODUCTION/ASSUMPTIONS

132……………..CONCLUSION

133-135……….ARC FAULT ANALYSIS

136-141……….COORDINATION STUDY

142-214……….SHORT CIRCUIT ANALYSIS

G) PROTECTIVE DEVICE COORDINATION STUDY

215……………..ASSUMPTIONS/RESULTS

216-222……….SHORT CIRCUIT CALCULATION

VI. BREADTHS

A) INTRODUCTION……………..223

B) HVAC BREADTH……………..224-231

C) STRUCTURAL BREADTH…..232-237

VII. CONCLUSION……………………238

VIII REFERENCES………………………239

IX. APPENDIX……………………………240

(LUMINAIRE & BREAKER SPECIFICATION SHEETS)

John P. Mulhern
Lighting/Electrical

New Jersey Center For Science, Technology, and Mathematics Education

Project Team

Owner:	Kean University
Architect + MEP	Cannon Design, Inc.
Structural:	Schoor Depalma Engineers & Consultants
Civil Engineer:	K.S. Engineers, P.C.
CM:	Provided by University
GC:	Terminal Construction Corporation

General Building Information

Address:	Union, NJ
Size:	6 Stories, 117,000 SF
Construction Dates:	Groundbreaking September 2008
Delivery Method:	Design-Bid-Build
Overall Cost:	$45,000,000

Electrical

- Primary service provided by PSE&G at 13.2 KV
- 3333 KVA transformer in main electrical room which steps down secondary service to 480/277V, 3ϕ, 4W
- 500 KW rated diesel generator for emergency
- 3^{rd} to 6^{th} floor fed by 1200A bus duct at 480V and is stepped down to 208/120V with a transformer on each floor and distribution panel

Structural

- Structural steel building
- System of spread footing ranging from 4' X 4' to 15' X 15'
- 5" slab on grade reinforced with 6x6 – W2.0 X 2.0 welded wire fabric
- Typical bay is 21' X 37'8"
- 3" 20 gauge composite galvanized metal floor deck with 3 ¼" lightweight concrete topping

Lighting

- Linear fluorescent luminaire with a direct distribution is utilized most throughout the building
- There are also many square downlights throughout the
- building
- Many fixtures have dimming capabilities
- There are many spaces with two sets of luminaires, ones with cool CCT's and ones with warm CCT's

Architectural

- Glass curtain wall with three different types of glass for most of façade makes it very transparent
- Double height lobby
- Partial green roof above auditorium
- Some features include executive center, 3D cave, exhibition space, and 300 person auditorium
- Roof system is composite metal deck with concrete topping with 4" rigid insulation

Mechanical

- 6 air handling units serve the building while one is is reserved for future restaurant tenant
- 300 ton rated cooling tower
- Geothermal system of 131 boreholes dug 500' down and spaced 20' apart
- VAV system utilized throughout building

II. BACKGROUND INFORMATION

The NJCSTME Building is a 6 story educational building for Kean University in Union, NJ. Construction broke ground September 2008 and is still currently currently so. There are many classrooms and labs for education. The building embraces the irregular layout and form of modern architecture. It contains a 280 seat auditorium, exhibition space, and even a 3D Cave. The new building reflects the advancement of modern technology in our age. Below are some descriptions of the systems designed for this building:

Fire Protection

The NJCFSTME building is designed with a preaction fire alarm system. The preaction system decreases the chances of accidental openings of the sprinkler heads. The building has a lot of computer and lab equipment, which would be very expensive to replace. This entire building is equipped with upright style sprinkler heads. The fire pump has a 75 hp motor rated at 1000 gpm. The jockey pump has a 4 hp motor rated at 30 gpm. There is a fire pump room on the first floor that houses the two pumps and other components of the fire protection system. The diesel generator powers some luminaires and the exit signs throughout the building during emergency power loss. There are speaker strobes in every hallway and large spaces such as the lower lobby. There are strobes in every other room. Every strobe device is rated at 75 candela luminous intensity. The fire command center is located on the second floor. Spray on fire proofing is also used where required by code for the structural steel members. The construction type is IB, Protected Noncombustible Construction. This type requires a two hour fire rating for floors, interior bearing walls and other structural elements such as columns, shafts, and emergency exit stair enclosures. Only the roof and some nonbearing exterior walls require 1 hour fire rating.

Structural

The structural system of this building predominantly consists of steel. The typical bay sizes for the 2nd through 6th floor. The slab on grade is 5" thick and is reinforced with 6x6 – W2.0xW2.0 welded wire fabric. The building has a system of spread footings that range from 4'x4' to 15'x15'. The largest footings are underneath the lobby and exhibition space because this is where the building rises the highest. The second through sixth floors have a typical floor system. These floors have 20 gauge composite galvanized metal floor deck that is 3" deep. This deck is covered with 3 ¼" lightweight concrete topping. The typical bay size is 21' x 37'8", and most of these beams are cambered 1 ¼". The lateral system consists of hollow structural steel braced frames and Chevron frames. The auditorium roof is 1 ½" galvanized metal deck supported by long span 36LH10 joists. Part of the main roof is also composed of 1 ½" galvanized metal deck, but it is supported by beams and not joists. The majority of the roof system is 3 ½" normal weight concrete over 2" composite metal galvanized deck.

Electrical

Public Service Electric and Gas Company (PSE&G) provides electrical service for this NJCSTME building from a utility pole on Kean Drive. The primary service runs underground in a duct bank to the outdoor pad mounted primary switch gear and PSE&G meter. The primary is at 13.2 KV and is stepped down at a 3333 KVA transformer to a 480Y/277V system.

II. BACKGROUND INFORMATION

The main transformer is owned by Kean University. On the 1st floor this transformer feeds distribution panel boards on the first and second floors, from which branch panels are fed. The normal power branch is distributed by a 1200A bus duct and 480Y/277V system from the 3rd through 6th floor. There are transformers for each floor which step down the voltage to 208Y/120V, and the secondary leads to a distribution panel. These distribution panels provide power to the multiple laboratory panels on each floor.

For emergency there is a packaged diesel generator set with weatherproof and sound attenuating enclosure and sub-base day tank. It is rated at 500 kW and at 0.8 power factor. There is an emergency, standby, and optional standby branch. These branches are in separate electrical rooms from the normal on each floor.

There are four automatic transfer switches in the Emergency Electrical Room. One is for the emergency lighting panels which are on a 480Y/277V system. The second ATS is for the standby branch, which provides backup power for HVAC dampers and lab fume hoods. The third ATS is also for a distribution panel, which serves the three elevator motors on the roof. Finally the fourth ATS serves the optional branch bus duct, which distributes backup power to miscellaneous lab equipment.

Construction

The contract for this building is a design-bid-build. The overall project bid cost is $45,000,000. The contract is a guaranteed maximum price type. The project broke ground in September 2008. The general contractor is Terminal Construction Company, who has performed construction services for the university in the past. They are based out of North Jersey and perform work in that area as well as New York City area.

Telecommunications

The telecommunications are tied in from the existing building Vaughn-Eames Hall. There is an existing duct bank outside the south wall of this hall. It runs from there to the intersection of Morris Avenue and Kean Drive. This is the point where the new duct bank is connected. The new duct bank runs to a manhole near the generator. The duct bank terminates at Server Room 1-35. The data wires are distributed throughout the building by 18" and 12" wide wire mesh metal cable tray.

Mechanical

There are 6 air handling units serving this building (AHU-1 through 6). AHU-7 will serve the future tenant in the restaurant space. There is a 300 ton closed cell cooling tower. The system designed is a four pipe system. The four pipe system does not have to be changed to heating or cooling for when the seasons change. Also some rooms can be heated while others can be cooled. The third floor classrooms and labs have radiant floor heating and one classroom on the fourth floor. A variable air volume system is utilized throughout the building.

Special Systems

There is a geothermal system designed for this building. It has 131 borehole wells dug 500 feet down and spacing 20 feet apart. The geothermal system has two water to water heat pumps. They both have capacities of 135 gpm. The geothermal system transfers heat to the three boilers by a heat exchanger.

II. BACKGROUND INFORMATION

Transportation

There are 3 elevators for transportation services in the NJCSTME Building. The elevators are powered by (3) 40 hp motors. The elevator machine room is on the roof and contains these motors. The elevators themselves are located in the circular core walls near the middle of the building. The interior is comprised of mostly stainless steel. It is illuminated by fluorescent recessed fixtures. There are two stairwells that exit to the outdoors. One is on the west side of the building adjacent to the lobby, and the other is the east side at the back of the auditorium. There is also a central staircase inside the circular core walls.

Lighting Systems

The lighting for this building is mostly fluorescent in order to meet ASHRAE Std. 90.1 requirements. This owner desires a LEED® Gold rated building, and this standard is cited for its power per area maximum values. Many spaces have two different fixtures with two different CCT's. The different CCT of the lamps provides flexibility for different functions. For instance, in the lobby there are linear fixtures with a 3500K CCT for the daytime general lobby function. However at night this lobby has functions where the cool CCT is not suitable. This is where the halogen track lighting is useful. There are low voltage control panels on every floor's electrical room. Many fixtures are equipped with dimming ballast for flexibility.

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

EXISTING SPACE CONDITIONS

Description of Space

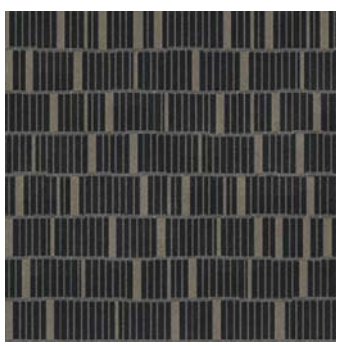
This is a simple college classroom. It seats 42 students with a desk for the teacher in the front of the classroom. The room is rectangular with approximate dimensions of 26' X 41'(Length X Width).

Glazing and Mullions

There are 2 ribbons of curtain wall glass across the one wall of this classroom, materials GL-1 and GL-3. GL-1 is a low emissivity glass with a clear glass substrate. It has a nominal visible light transmittance of 70%, so the reflectance is 30%. The glass is almost full height and is made mostly of GL-1. There is a small ribbon of type GL-3 glazing at the floor level. GL-3 is the same type as GL-1 only it is acid etched. The mullions have an aluminum sliver metallic finish with an assumed reflectance of 75% taken from pg. 1-22 of the IESNA Handbook.

Floor

The floor is covered with 3'x3' CPT-1 carpet tiles in the color 708 stone. It is tufted and textured loop pile carpet made of nylon. Assume its reflectance value is 0.06



CARPET TILES

Ceiling

The ceiling is made of 2' X 4' ACT with 1' gaps between for placement of the Equation ™ 1' X 4' luminaires. The majority of the ceiling is at a height of 9'6". Near the blackboard the ceiling steps down to 8'0"and is made of white painted gypsum wall board. There is a 24" wide slot that is 12" height along the curtain wall. This slot is tucked in above the 9'6" ceiling height and holds the shade for the glazing. Assume its reflectance value is 0.75

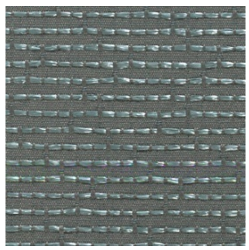
IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

EXISTING SPACE CONDITIONS (CONT'D)

Walls and Doors

The east and west wall of the classroom is made of fabric wall panel. The material is mostly comprised of polyester Assume its reflectance value is 0.17.



PALLADIUM FABRIC WALL PANEL

A small portion near the adjacent to the glass board wall is white painted gypsum wall board. Assume its reflectance value is 0.5. The doors are made of metal with some glazing and a stainless steel kick plate near the bottom. Assume its reflectance value is 0.4

The north wall is made of painted white gypsum board. The doors on this wall are wooden with a hollow metal core type. Assume the reflectance value of these doors is 0.5. There is back painted glass writing board on the wall. Assume its reflectance value is 0.5

BACK PAINTED GLASS

The south wall is a full height glass curtain wall with silver metallic aluminum mullions. The glazing is described before in the "Glazing and Mullions" section.

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

EXISTING SPACE CONDITIONS (CONT'D)

Furniture

Not much information was given about the furniture in the schematics. There are tables that seat 6 people across. There are 7 of these tables which seat 42 people. Assume the tables are made out of plastic laminate with a reflectance of 0.35 and produce a diffuse light distribution. Assume the teacher's desk at the front of the classroom is made of polished wood and has a semi-specular distribution. Also an assumption was made that its reflectance is 0.4.

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

LIGHTING DESIGN CRITERIA

Type of space

- Classroom-General Reading

Appearance of Space

- The appearance of the space will be very bright with full height curtain wall and white ACT ceiling
- The luminaires should be some sort of white finish to blend in with the white ACT ceiling
- Should have appearance of visual clarity
- The ceiling height drops down 1'0" right near the professor's desk and writing board in the front of the classroom

Color Appearance (Color Contrast)

- There should be a luminance contrast between the glass writing board and the other walls to draw attention (no more than 10:1)
- The lamps should have a cool CCT to keep the students awake and not feeling tired
- Luminaires should be rectangular to go along with architecture of room

Daylight Integration and Control

- This is a very important criteria seeing how the client desires a LEED certified building
- There are solar shades on the south facade for the summer so the daylight levels will be variable
- Indoor shades could be controlled as well
- Photo sensors could be installed to detect daylight levels seeing how this project will be certified LEED Gold

Direct Glare

- Will be a problem with full height south facing curtain wall
- Solar shades will be used and retractable shades indoors
- Luminaires should avoid causing veiling reflections for reading and writing tasks
- Luminaires should have prismatic lenses or louvers to properly deal with glare

Light Distribution on Surfaces

- Back painted glass writing board need to be illuminated close to uniformity

Light Distribution on Task Plane

- Light distribution should be as uniform as possible

Luminances of Room Surfaces

- More lighting will be required due to the darker fabric walls, because not as much diffuse light will provide visual comfort

I. LIGHTING DEPTH

IV. LIGHTING DEPTH

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B.) CLASSROOM REDESIGN

LIGHTING DESIGN CRITERIA (CONT'D)

Modeling of Faces and Objects

- The ceiling drops down from 9'6" to 8'0" so recessed fixtures could be useful there to model the teacher and writing board
- Avoid concentrated down lighting because it causes harsh shadows

Points of Interests

- The back painted glass writing board should be the only point of interest so students will concentrate

Source/Task/Eye Geometry

- Light distributions should be cut off mostly towards nadir to prevent glare in the distance when students are observing the writing board with luminances at steep angles from luminaires

System Control and Flexibility

- Should control for daylight
- Need a mode for when the projector is on

Illuminance (Horizontal)

- No criteria listed in IESNA handbook
- 30 fc will suffice considering the main occupants are young college students
- Daylight from the curtain wall will help the illuminance level

Illuminance (Vertical)

- 20 fc on the glass writing board

ASHRAE 90.1 Requirements

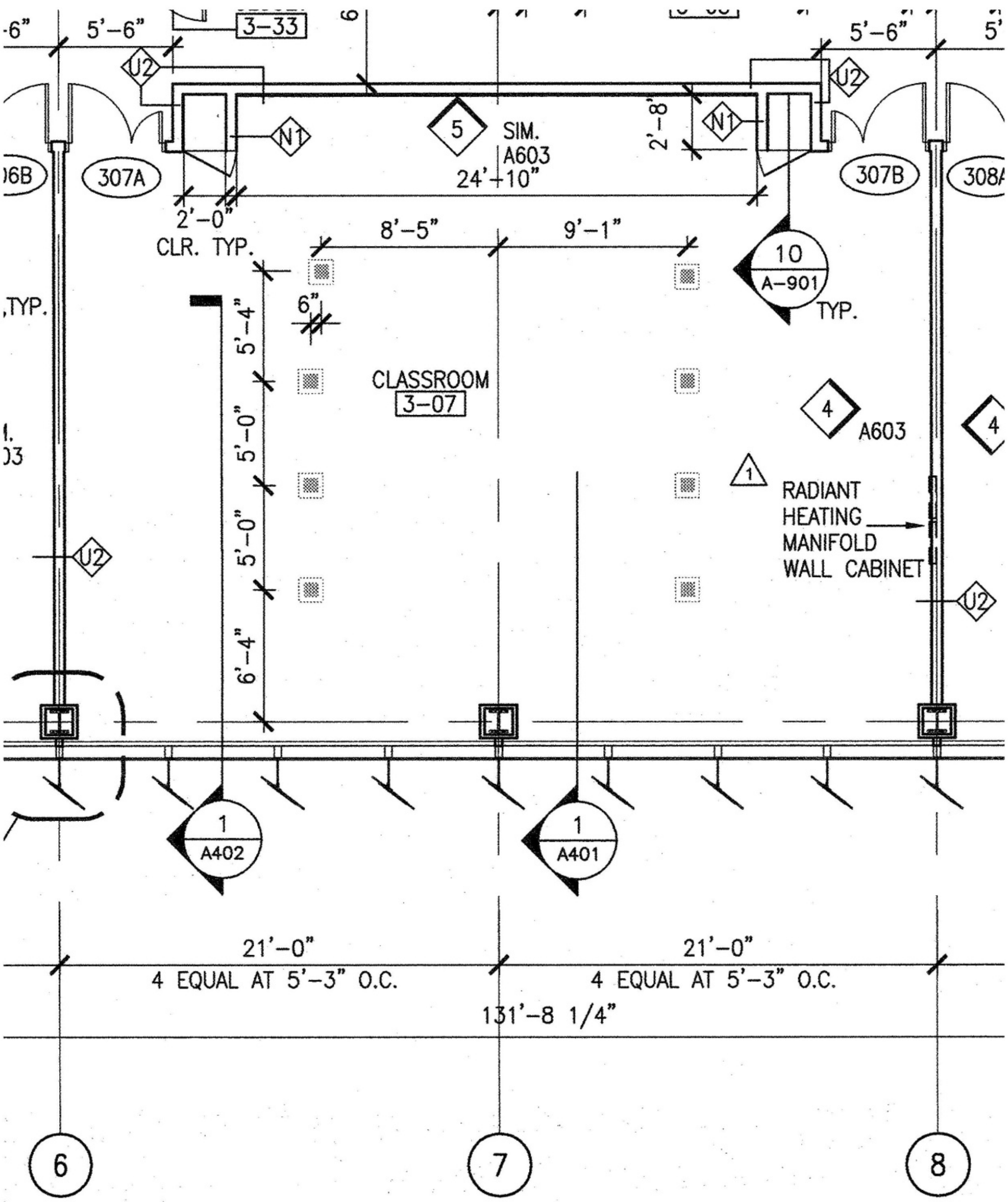
- For Classroom/Lecture → 1.4 W/ft^2
- A classroom also requires an automatic light shutoff 30 minutes after people leave the space
  - An occupancy sensor of some sort will be required

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

PLANS

<u>Classroom Plan</u> (N.T.S.)
"Drawing A-103"

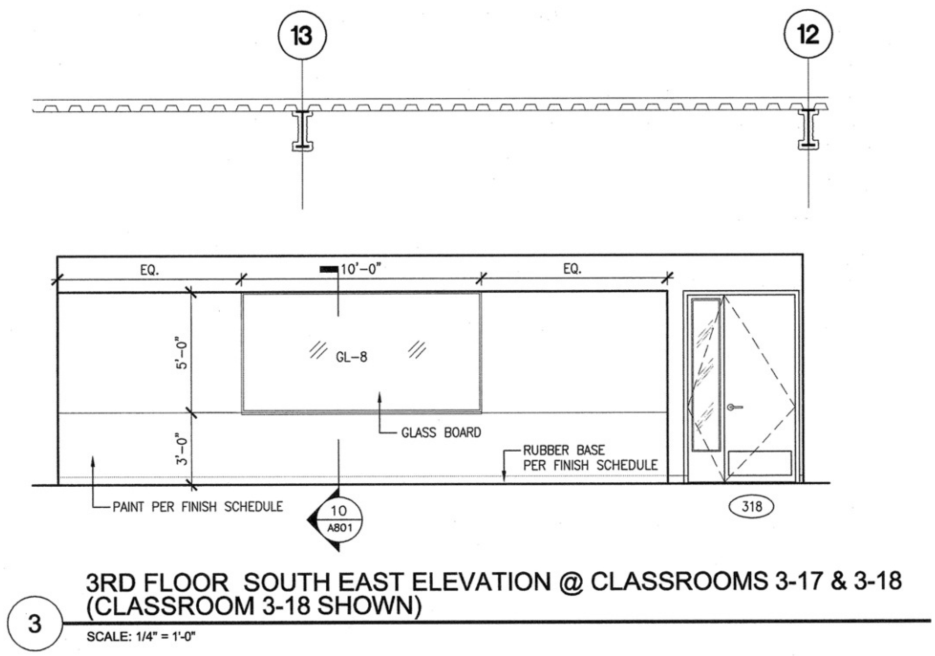


IV. LIGHTING DEPTH

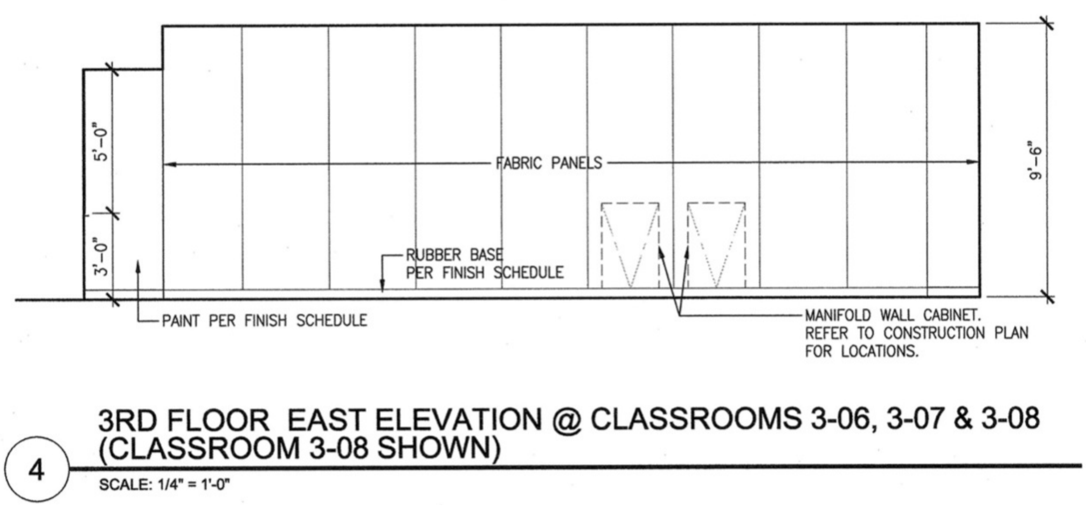
B.) CLASSROOM REDESIGN

PLANS (CONT'D)

Classroom Southeast Elevation (N.T.S.)
"Drawing A-603"



Classroom East Elevation (N.T.S.)
"Drawing A-603"

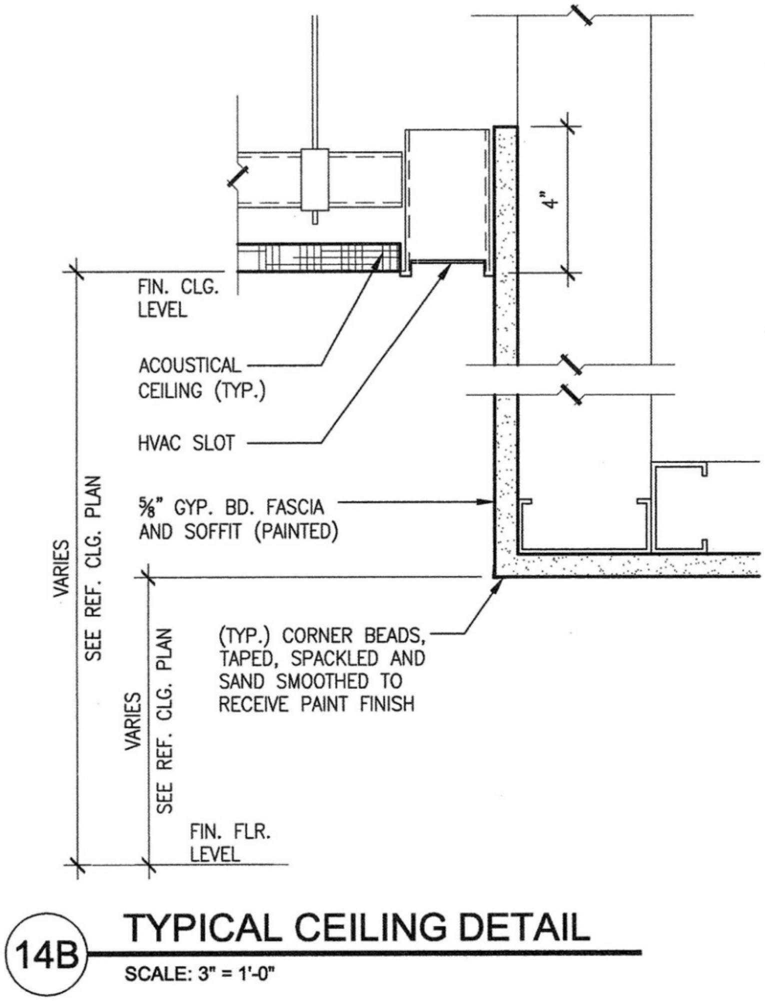


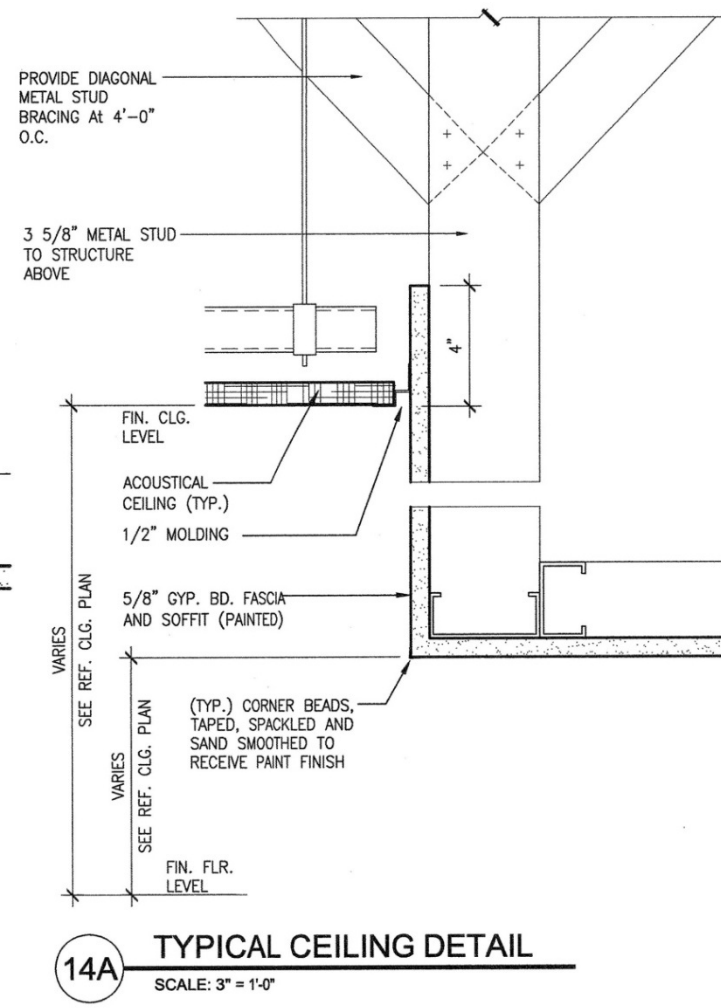
IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

PLANS (CONT'D)

<u>Ceiling Details</u> (N.T.S.)
"Drawing A-810"





IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

DESIGN EXPLANATION

Design Concept

The circuit board concept was translated into this space by providing only recessed and semi recessed lighting in order to have a clean appearance for the ceiling. This design is intended to achieve a subjective impression of visual clarity by providing uniform illumination onto the task plane with a direct fixture. The whiteboard will have a higher luminance than the lateral walls so that students will concentrate on it during class. The peripheral walls are also lit to make the room feel more spacious.

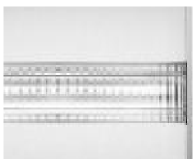
Fixture Mounting

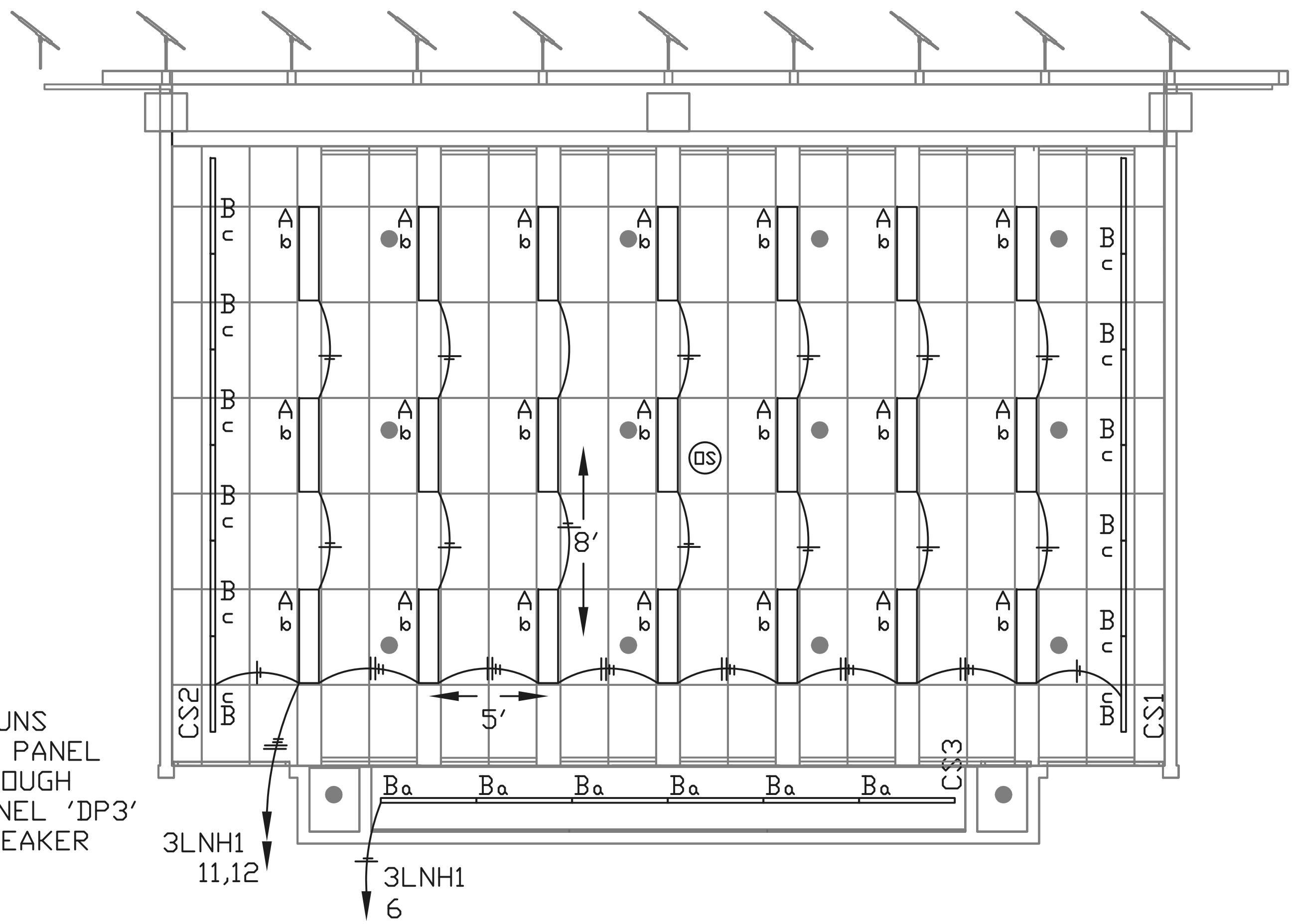
The luminaires chosen were both 1' x 4' linear fluorescent, however the wall washers are semi recessed while the fixture for the general illumination is recessed. The wall washers will be cut into the tile and mounted in a semi recessed fashion. The fixtures for general illumination are mounted recessed into a 1' gap between 2'x4' ceiling tiles.

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

LUMINAIRE SCHEDULE

TYPE	IMAGE	MANUFAC-TURER	CATALOG #	DESCRIPTION	LAMP	VOLT-AGE	BALLAST	WATTS
A		ZUMTOBEL	ML4U-14-1285-MP-DE_2	1'X4' LINEAR FLUORESCENT W/ MICRO PYRAMIDAL OPTIC AND PRISMATIC LOWER LENS AND PRISMATIC ACRYLLIC SIDES	(1) 28W T5 4' LINEAR FLUORE-SCENT	277V	LUTRON ECO-10 CAT# ECO-T528 - 277-1	38.8
B		ELLIPTIPAR	F210-T128-L-02-V-00-0	1'X4' LINEAR FLUORESCENT WALLWASHER W/ SPECULAR REFLECTOR	(1) 28W T5 4' LINEAR FLUORE-SCENT		LUTRON ECO-10 CAT# ECO-T528 - 277-1	38.8



NOTE: ALL HOMERUNS TO POWER PANEL '3LNH1' THROUGH DIMMING PANEL 'DP3' (BRANCH BREAKER TYPE)

1 CLASSROOM 3-07 - LIGHTING RCP

SCALE: 1/8"=1'0".

AE 482W
JOHN MULHERN

NEW JERSEY CENTER FOR SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION

SUBMITTED FOR PROF. DANNERTH APRIL 7, 2009

CLASSRM. LIGHTING RCP DIAGRAM

IV. LIGHTING DEPTH

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B.) CLASSROOM REDESIGN

CALCULATIONS

<u>Light Loss Factors</u>

Note : All calculations done in accordance with IESNA Handbook pp. 9-20 to 9-23 and Chapter 9 of AHSRAE Standard 90.1-2007. Assume all ballast factors are 1.0 unless otherwise noted.

<u>**A**</u>

- Category V: Opaque unapertured top enclosure, translucent unapertured bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = $e^{(-At^B)} = e^{[-(0.078)(1\ year)^{0.53})}$
- LDD=0.902
- RCR ≈ 3, DD =10% → RSDD =0.98
- LLD = 2660 Mean lumens/2900 Initial Lumens = 0.917
- BF = 1.0
- PF = 0.95
- Total LLF = (0.902)(0.98)(0.917)(1.0)(0.95) = 0.77

<u>**B**</u>

- Category V: Opaque unapertured top enclosure, translucent unapertured bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = $e^{(-At^B)} = e^{[-(0.078)(1\ year)^{0.53})}$
- LDD=0.902
- RCR ≈ 3, DD =10% → RSDD =0.98
- LLD = 2660 Mean lumens/2900 Initial Lumens = 0.917
- BF = 1.0
- PF = 0.95
- Total LLF = (0.902)(0.98)(0.917)(1.0)(0.95) = 0.77

IV. LIGHTING DEPTH

____

B.) CLASSROOM REDESIGN

CALCULATIONS(CONT'D)

Power Density

Note : All calculations done in accordance with IESNA Handbook pp. 9-20 to 9-23 and Chapter 9 of AHSRAE Standard 90.1-2007. Assume all ballast factor are 1.0 unless otherwise noted.

A

- 21 Luminaires
- Ballast input current of 0.14 A for
- 277 V x 0.14A x 21 luminaires = 815 W

B

- 18 Luminaires
- Ballast input current of 0.14 A for
- 277 V x 0.14A x 18 luminaires = 698 W

- Room Area = 1284 SF
- 1.4 W/SF requirement ASHRAE Std. 90.1
- 1513 TOTALWATTS /1284 SF
- 1.18 W/SF
- **1.18 W/SF < 1.4 W/SF ASHRAE STD. 90.1 REQUIREMENT**

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

CLASSROOM SCENE RESULTS

In the class mode, Zone “b”, the group of fixtures for general illumination, is dimmed to 75% output. This is done to save energy over the course of time because the average horizontal illuminance is very close to the 30 fc criteria at this light output. The peripheral wall washers and the whiteboard ones as well are dimmed to 25% of their light output. However, the whiteboard is emphasized compared to the other peripheral elements because its reflectance value is much higher than the fabric walls.

Calculation Summary								
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min	CV
Horizontal Task Plane	Illuminance	Fc	7.65	11.4	4.6	1.66	2.48	N.A.
Writing Board_1_Writing Board	Illuminance	Fc	1.74	2.5	0.8	2.18	3.13	N.A.
Fabric Wall_2_Fabric Wall	Illuminance	Fc	9.63	19.2	2.8	3.44	6.86	0.46

FIG. C-1
CALCULATION SUMMARY CLASSROOM SCENE

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

CLASSROOM SCENE RESULTS (CONT'D)

CLASSROOM SCENE DIMMING LEVELS			
	Zone "a" - Whiteboard Wallwash	Zone "b" - General Illumination	Zone "c" - Wall Washers
Dimming Level	25%	75%	25%

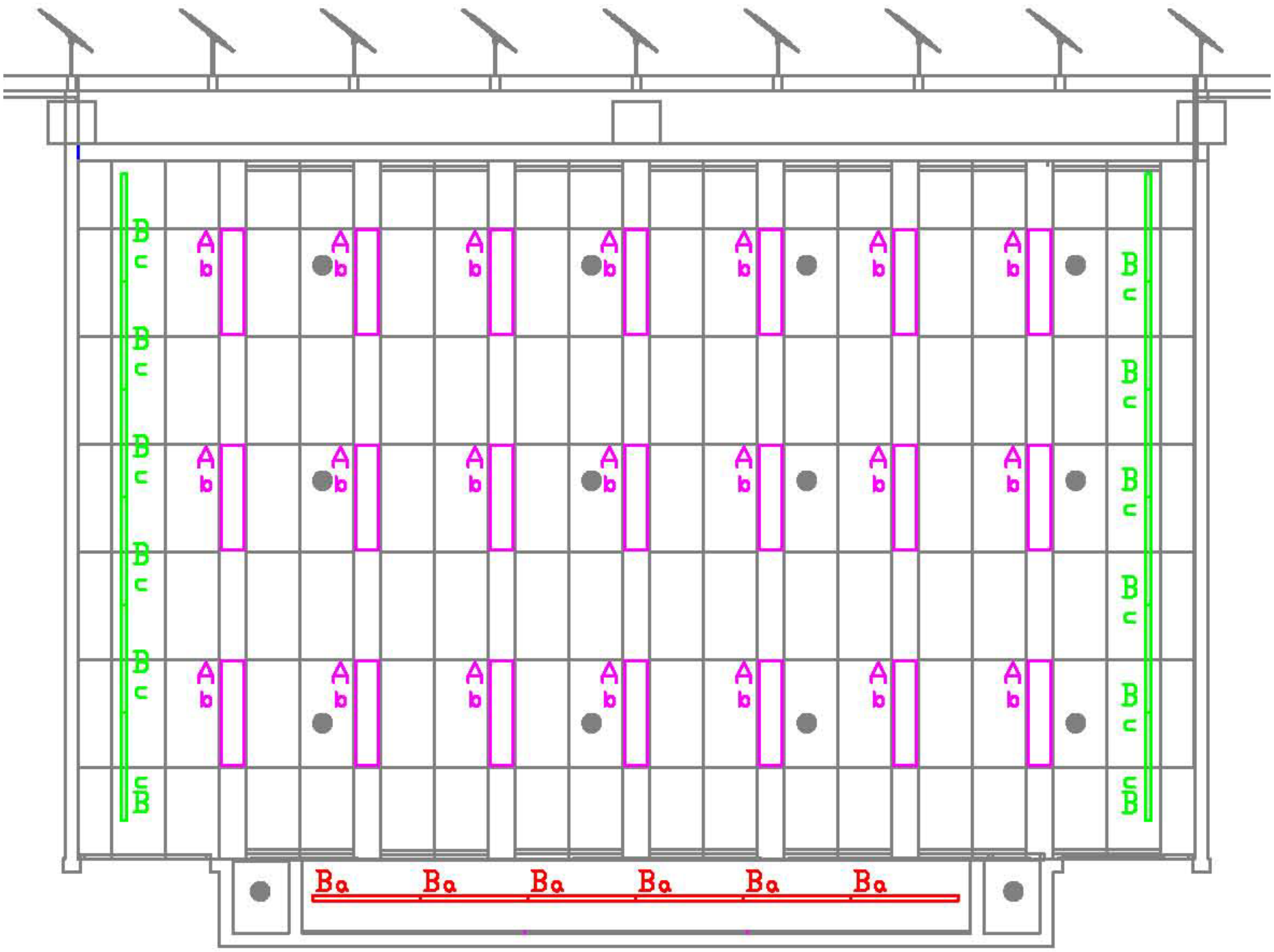


FIG. C-1
LIGHTING RCP

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

CLASSROOM SCENE RESULTS (CONT'D)

FIG. C-2
PERSPECTIVE RENDERING OF WHITEBOARD

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

CLASSROOM SCENE RESULTS (CONT'D)

Classroom Scene (cont'd)

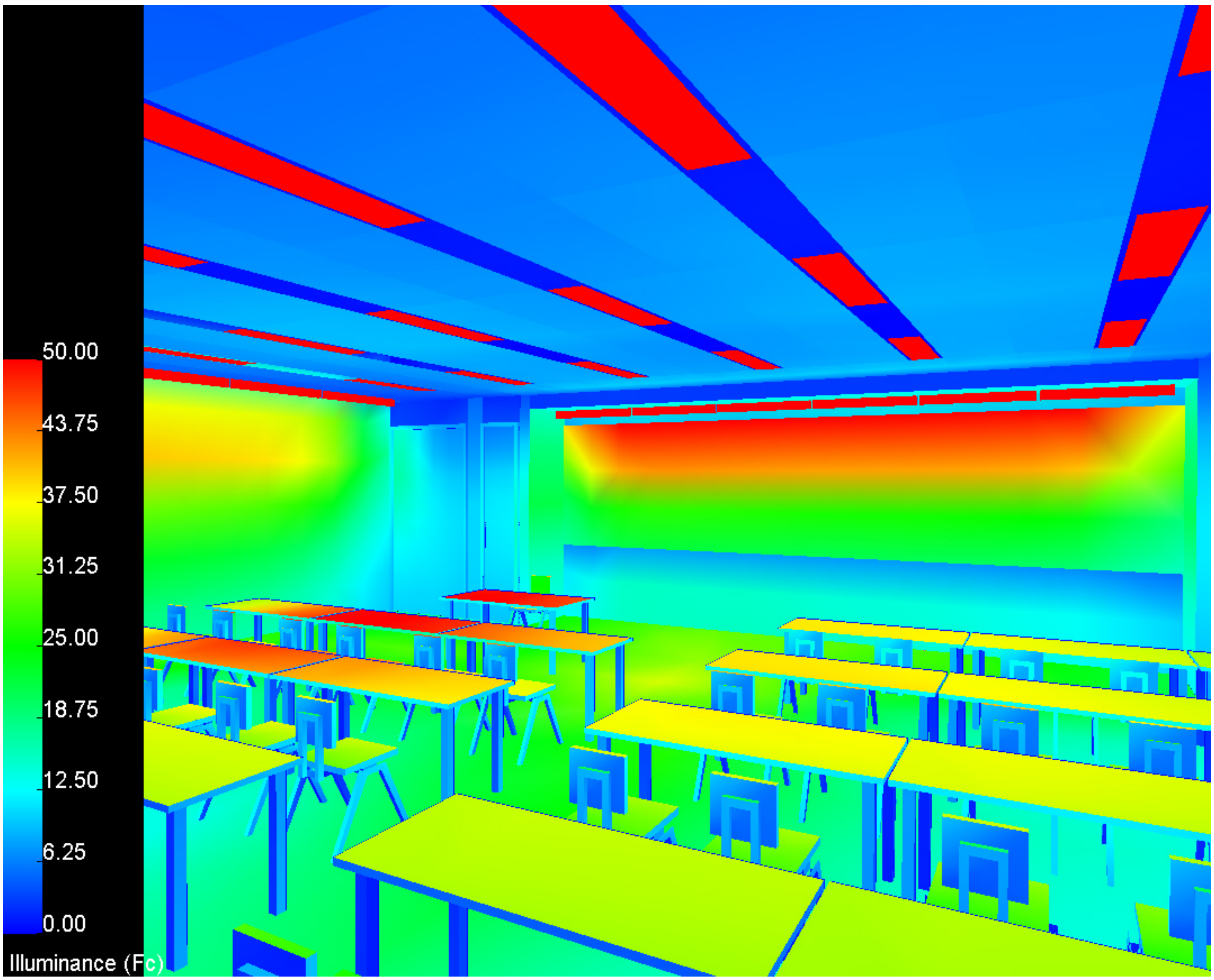


FIG. C-2B
PERSPECTIVE ILLUMINANCE PSEUDOCOLOR OF WHITEBOARD

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

CLASSROOM SCENE RESULTS (CONT'D)

Classroom Scene (cont'd)

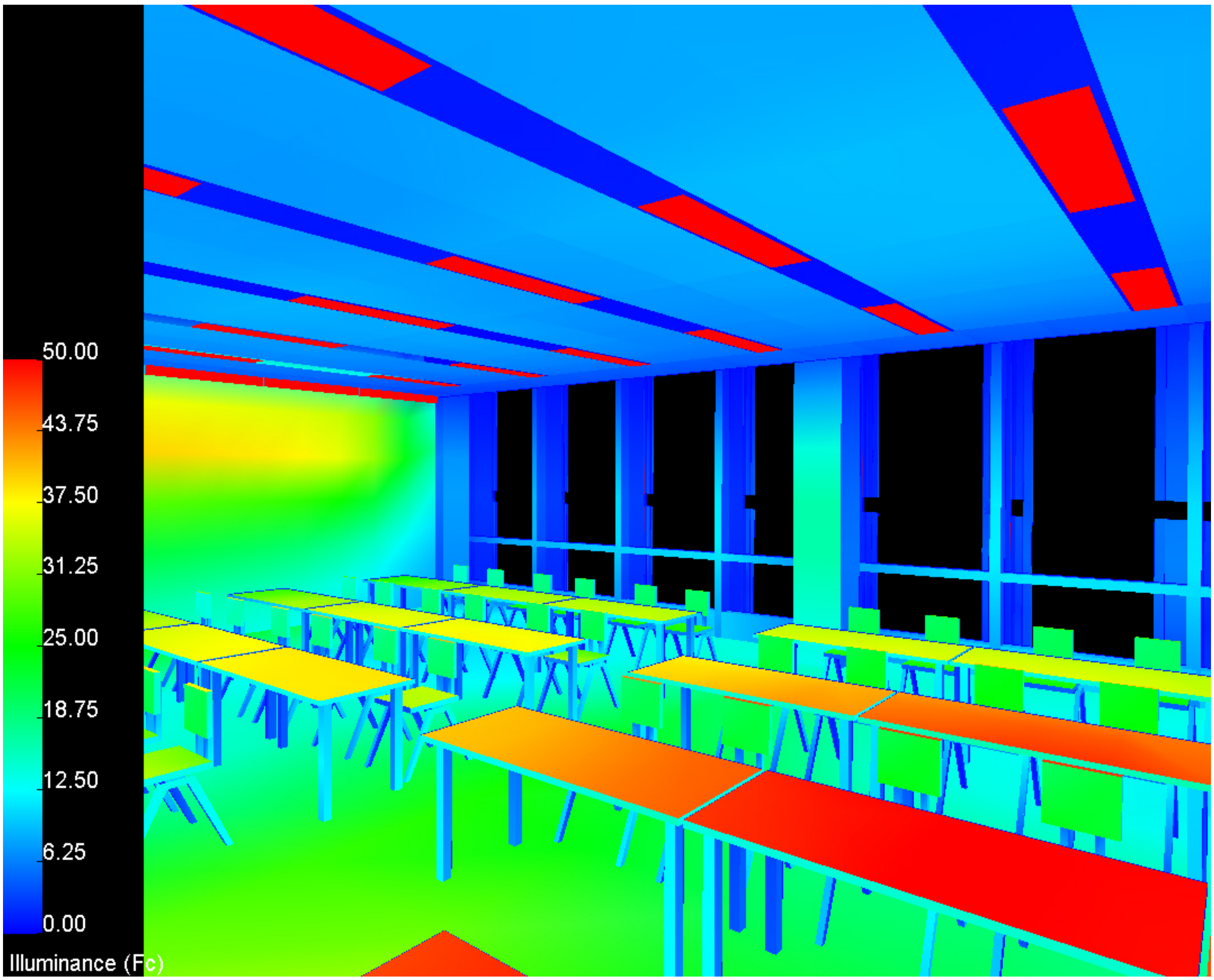
FIG. C-3A
PERSPECTIVE RENDERING OF SOUTH FACING CURTAIN WALL

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

CLASSROOM SCENE RESULTS (CONT'D)

<u>Classroom Scene (cont'd)</u>



<u>FIG. C-3B</u>
PERSPECTIVE ILLUMINANCE PSEUDOCOLOR OF SOUTH FACING CURTAIN WALL

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

CLASSROOM SCENE RESULTS (CONT'D)

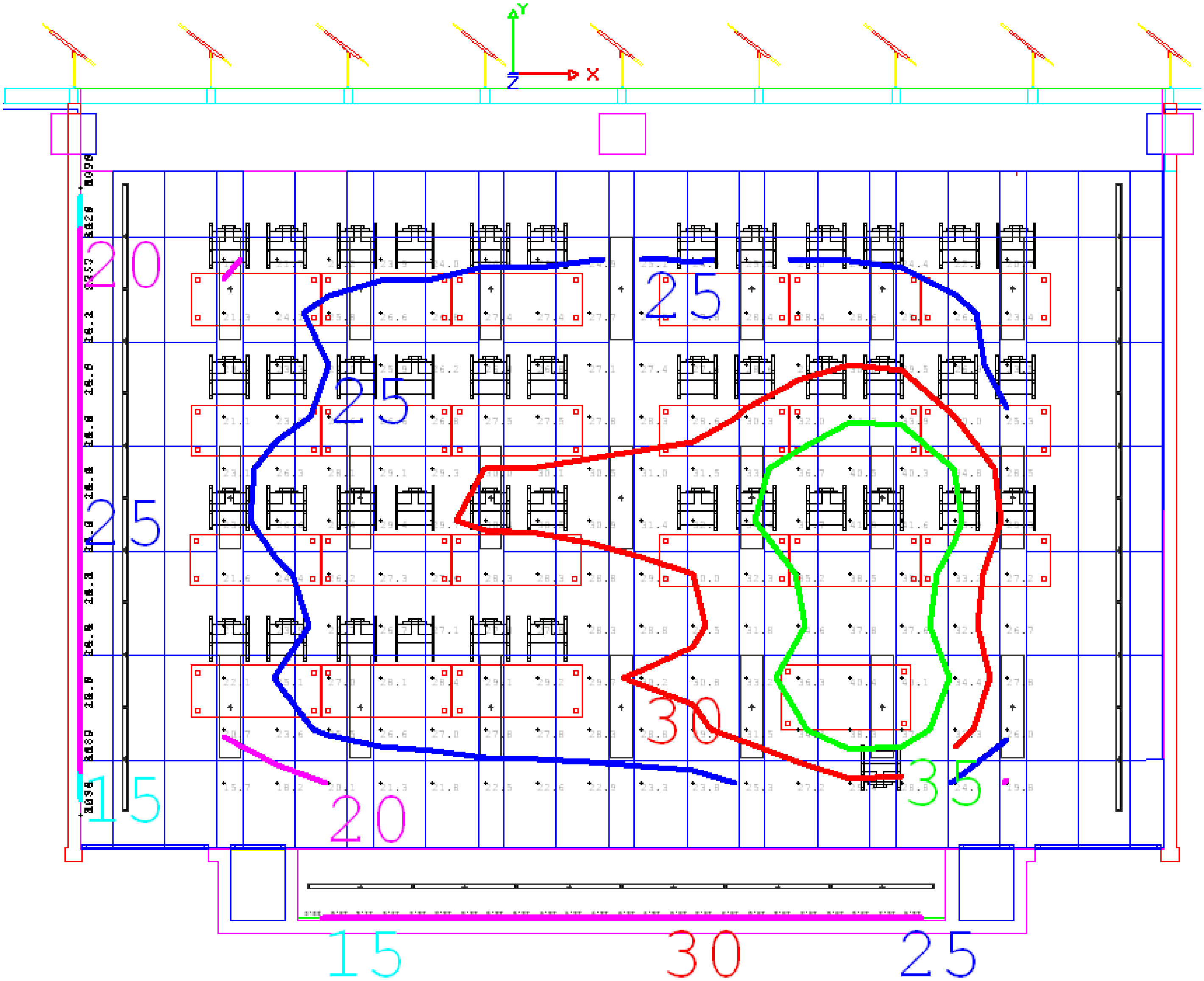


FIG. C-4
ILLUMINANCE ISOLINE PLAN

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

PROJECTOR SCENE RESULTS

In projector mode, the type "A" luminaires are dimmed to 20 % output. The fixtures grouped in Zone "a", which light the whiteboard, are turned off since they will be behind the projection screen. These last two dimming levels are important. They are dimmed to a very low output so that spill light does not make it difficult for the students to observe the projector screen. The criteria for vertical illuminance on the projector was stated as 5 fc earlier in the report. As shown below in Figure C-6, the maximum illuminance value is 3.4 fc, which is far below the requirement. The type "A" fixtures could have been dimmed to 10% output, but some light is needed for the students to take notes.

Calculation Summary								
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min	CV
Horizontal Task Plane	Illuminance	Fc	7.83	11.6	5.3	1.48	2.19	N.A.
Writing Board_1_Writing Board	Illuminance	Fc	1.87	2.6	0.9	2.08	2.89	N.A.
Fabric Wall_2_Fabric Wall	Illuminance	Fc	17.68	31.9	4.7	3.76	6.79	0.42
Projector Screen	Illuminance	Fc	2.86	3.4	1.8	1.59	1.89	0.16

FIG. C-5
CALCULATION SUMMARY PROJECTOR SCENE

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

PROJECTOR SCENE RESULTS (CONT'D)

PROJECTOR SCENE DIMMING LEVELS			
	Zone "a" - Whiteboard Wallwash	Zone "b" - General Illumination	Zone "c" - Wall Washers
Dimming Level	OFF	20%	25%

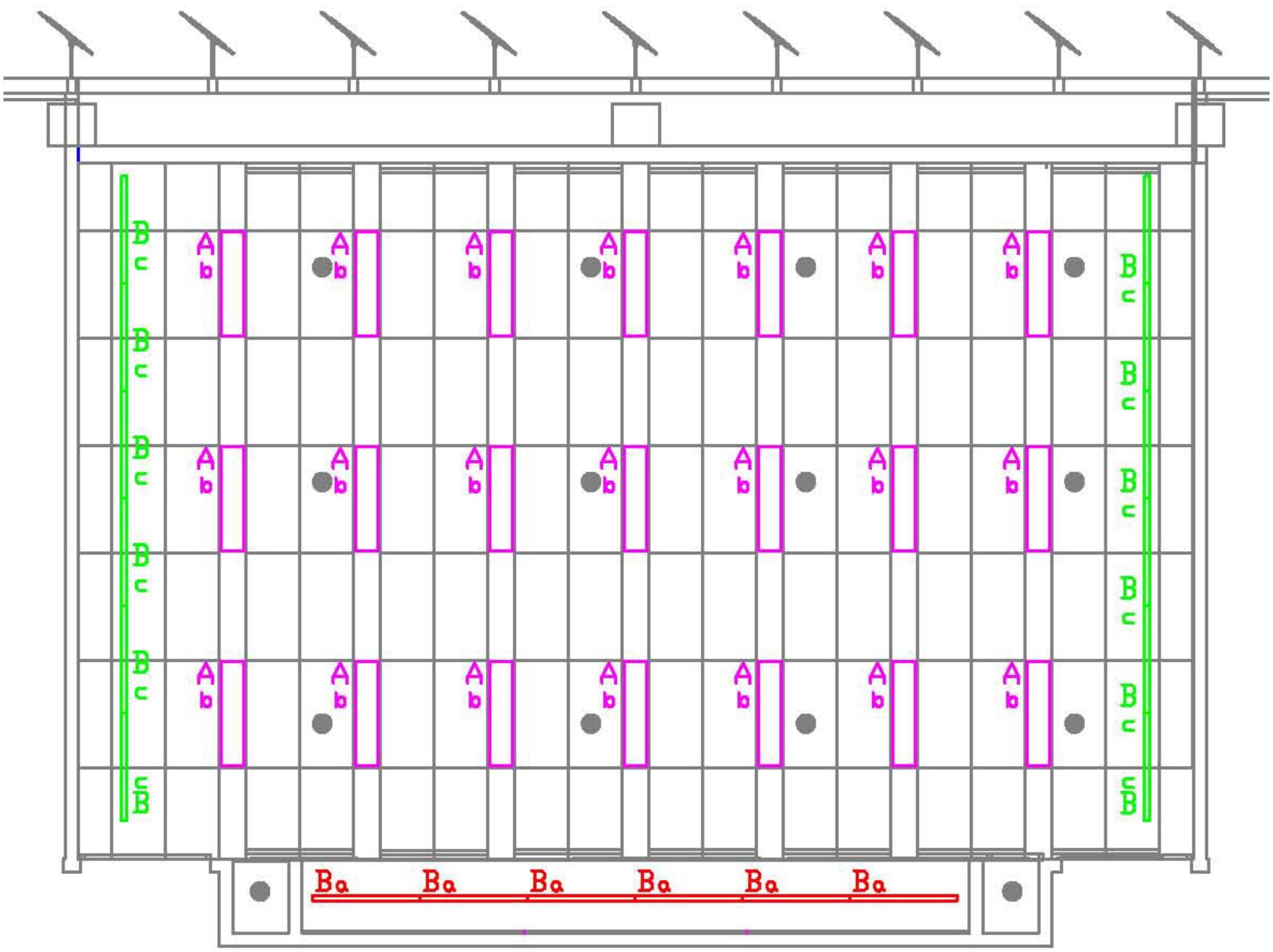


FIG. C-6
LIGHTING RCP

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

PROJECTOR SCENE RESULTS (CONT'D)

FIG. C-7A
PERSPECTIVE RENDERING OF WHITEBOARD

IV. LIGHTING DEPTH

B.) CLASSROOM REDESIGN

PROJECTOR SCENE RESULTS (CONT'D)

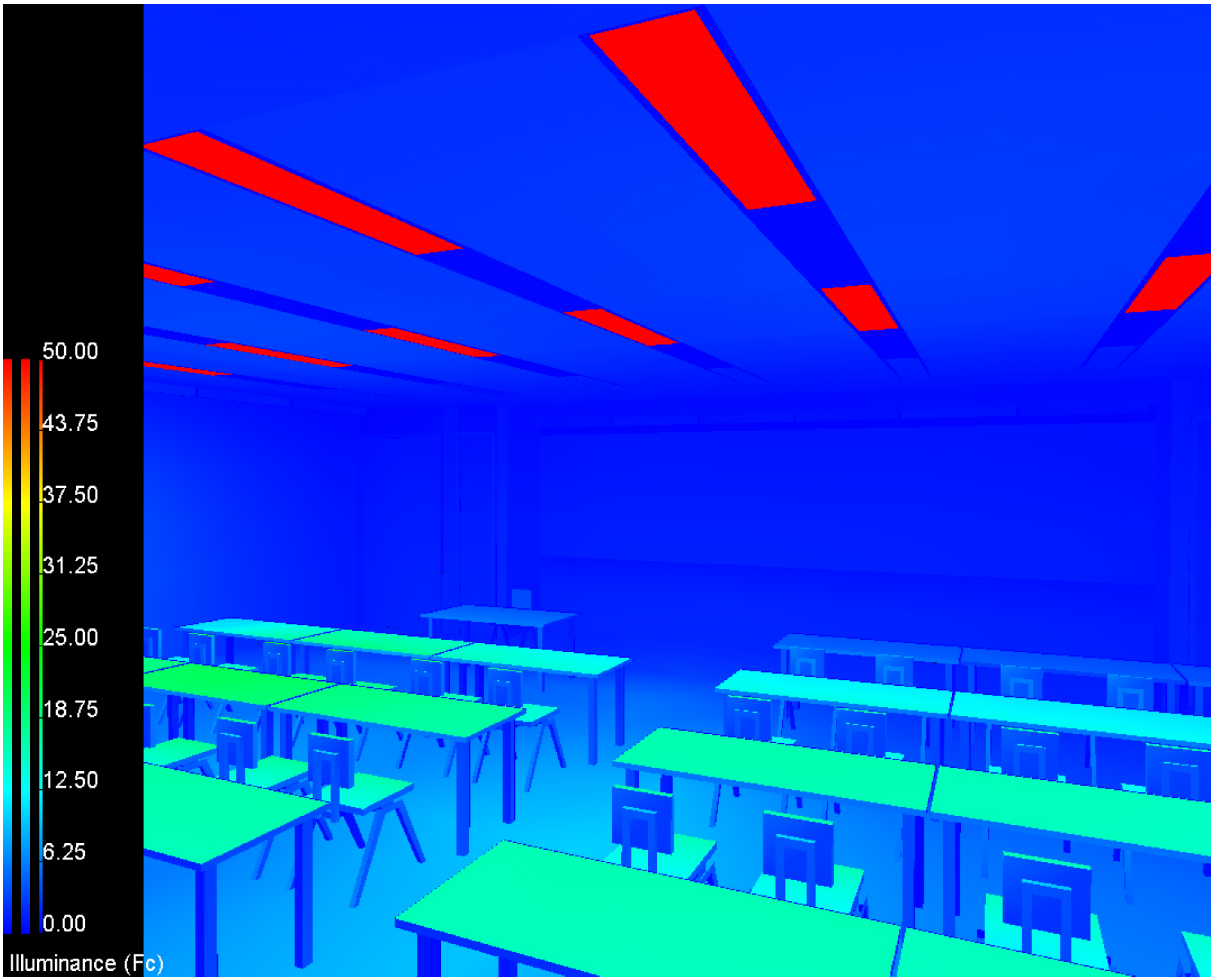


FIG. C-7B
PERSPECTIVE ILLUMINANCE PSEUDOCOLOR OF WHITEBOARD

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

EXISTING SPACE CONDITIONS

Description of Space

This lobby will be the highlight of all the spaces in this building. It is a double height lobby with a 19' ceiling height. The walls in the plan north and plan south direction are partially double height curtain wall. The ceramic tile curved wall is along the plan east wall. There is a curving staircase to the second floor with glass railing and stainless steel handle. There are 8 cylindrical aluminum columns in the interior of the space. Occupants will be able to see part of the second floor exhibition space and the second floor elevator lobby with openings guarded by glass railings

Tasks

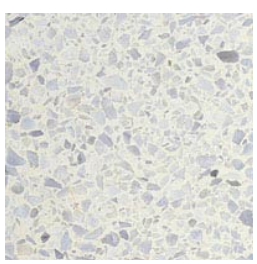
There are multiple tasks in this lower lobby building. The first task is simple lounging. Students will be there talking and possibly reading in there. There may be a welcome desk for information as well. There is no furniture in the schematics because the university is arranging the furniture and making the selections. Kean University will also hold parties and galas at times so different scenes will be needed. There will also be circulation to the elevator lobby and staircase for the occupants to get to their respected spaces in the building.

Glass Curtain Wall

There is double height curtain wall in this space. The glass is only the type GL-1. GL-1 is a low emissivity glass with a clear glass substrate. It has a nominal visible light transmittance of 70%, so the reflectance is 30%. The mullions have an aluminum sliver metallic finish with an assumed reflectance of 75% taken from pg. 1-22 of the IESNA Handbook.

Floor

The floor is made of TZ-1 Terazzo tile. The size of the tile is 11-13/16" X 11-13/16". TZ-1 is a custom selection with no picture, so for future renderings assume it is TZ-2 with its picture shown below.



TERAZZO TILE

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

EXISTING SPACE CONDITIONS (CONT'D)

Ceiling

The ceiling is 2'x8' fiberglass plank with slots running the entire width of the building for the light in the ceiling to shine through. There are also slots along the perimeter of the lobby. Assume its reflectance value is 0.8.

FIBERGLASS PLANK CEILING

There are 2' wide openings between each row of ceiling tiles running north and south the length of the lobby. There are fluorescent luminaires (FQ-5) pendant mounted in these openings to the finish ceiling height of the lobby. There is a cove along the circular elevator core wall made of painted white gypsum.

Walls

Most of the walls in the lobby are made of the double height curtain wall described previously. Some of the east walls are white painted gypsum wallboard. The elevator lobby walls are made of a plastic laminate panel PLAM-1 with silver leaf finish.

PLASTIC LAMINATE PANELS

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

EXISTING SPACE CONDITIONS (CONT'D)

The elevator circular core walls consist of a ceramic tile pattern of the following colors:

CT-1: Vanniglia

CT-1A: Cacao

CT-1B: Lavangna

CT-1C: Paprika

CT-1D: Oceano

CERAMIC TILE PATTERN COLORS

CERAMIC TILE PATTERN COLORS

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

EXISTING SPACE CONDITIONS (CONT'D)

Stairs and Railings

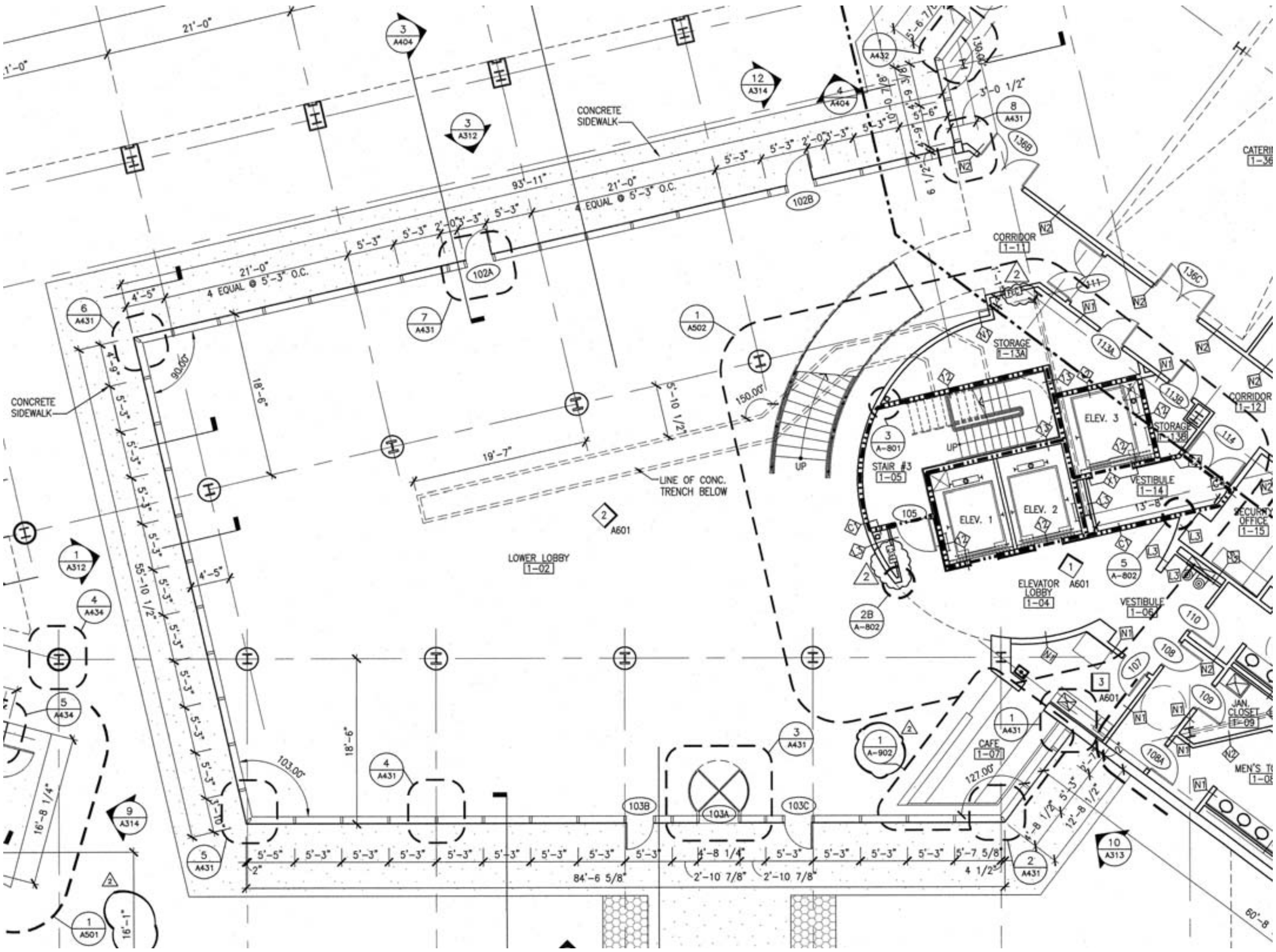
The monumental staircase curves going up to the 2nd floor. The stairs made of stainless steel and railings made of clear glass GL-6. The railings for the exhibition space on the second floor are made of this material as well. The 2nd floor elevator lobby railings visible in the lobby are made of double side mirror back acid etched glass GL-9. The stairs are made of terrazzo tile TZ-1 stated above in the floor section.

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

PLANS

<u>Lower Lobby Plan</u> (N.T.S.)
"Drawing A-101"

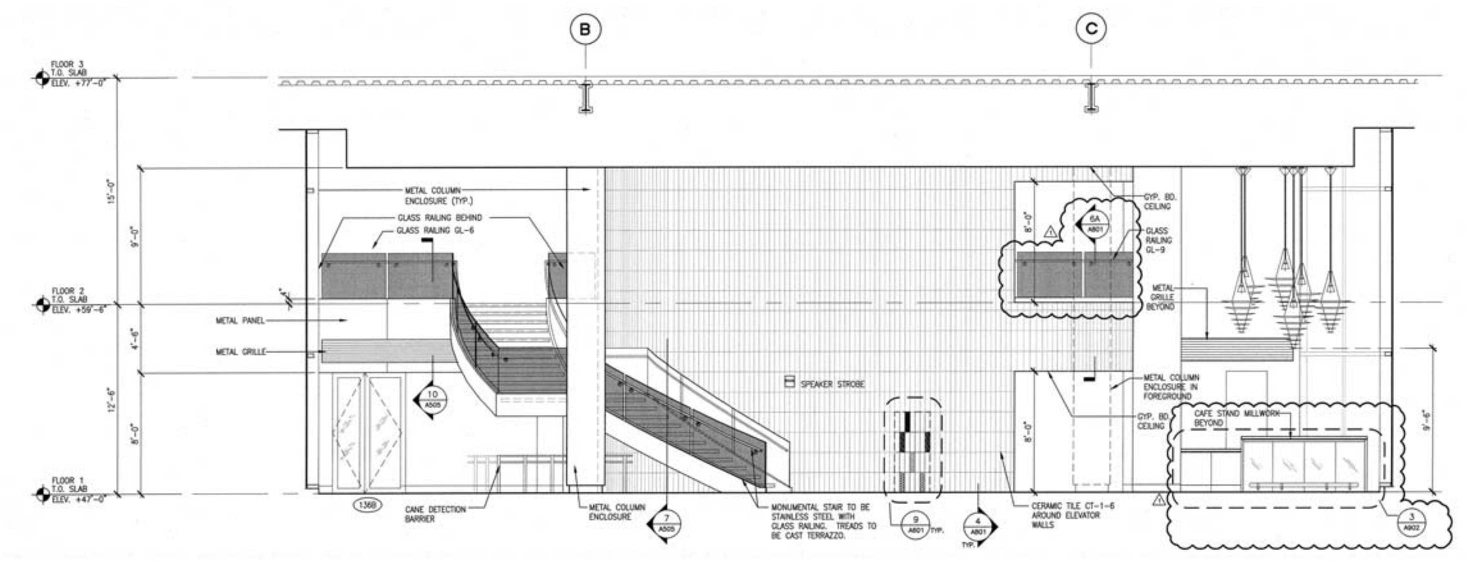


IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

PLANS (CONT'D)

Lower Lobby 1ST AND 2ND FLOOR ELEVATION (N.T.S.)
"Drawing A-601"



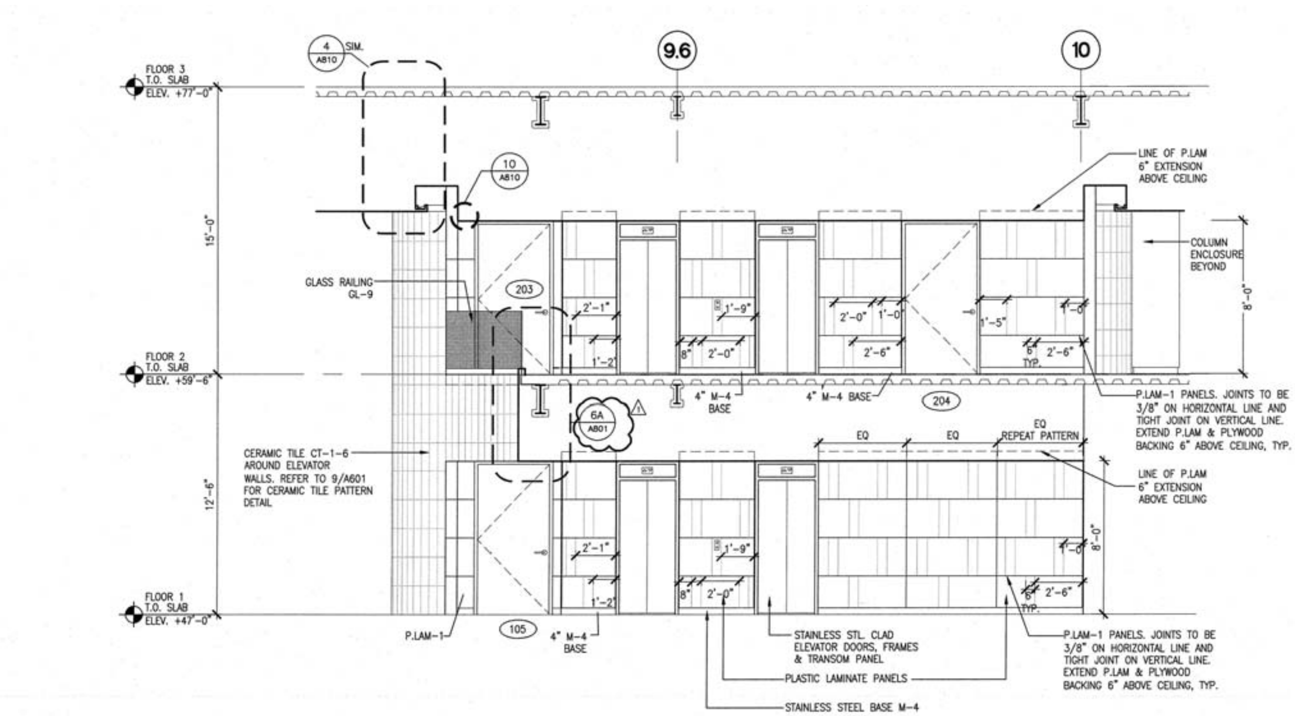
2 1ST AND 2ND FLOOR LOWER LOBBY ELEVATIONS
SCALE: 1/4" = 1'-0"

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

PLANS (CONT'D)

Lower Lobby 1ST And 2ND Floor Elevator Lobby Elevation (N.T.S.)
"Drawing A-601"



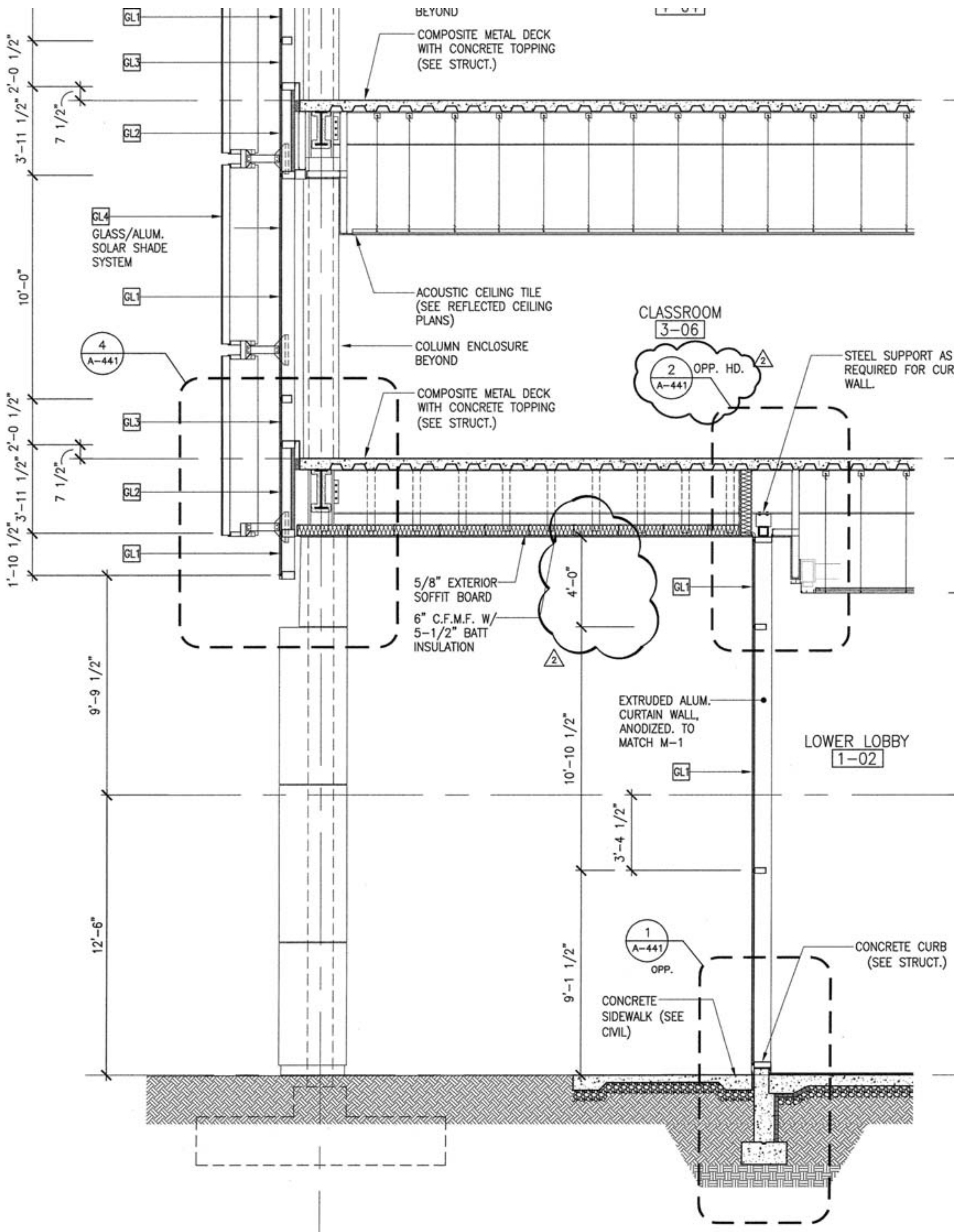
1 1ST AND SECOND FLOOR ELEVATOR LOBBY NORTH ELEVATIONS
SCALE: 1/4" = 1'-0"

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

PLANS (CONT'D)

<u>Lower Lobby Section South Curtain Wall</u> (N.T.S.)
"Drawing A-402 Detail #1"

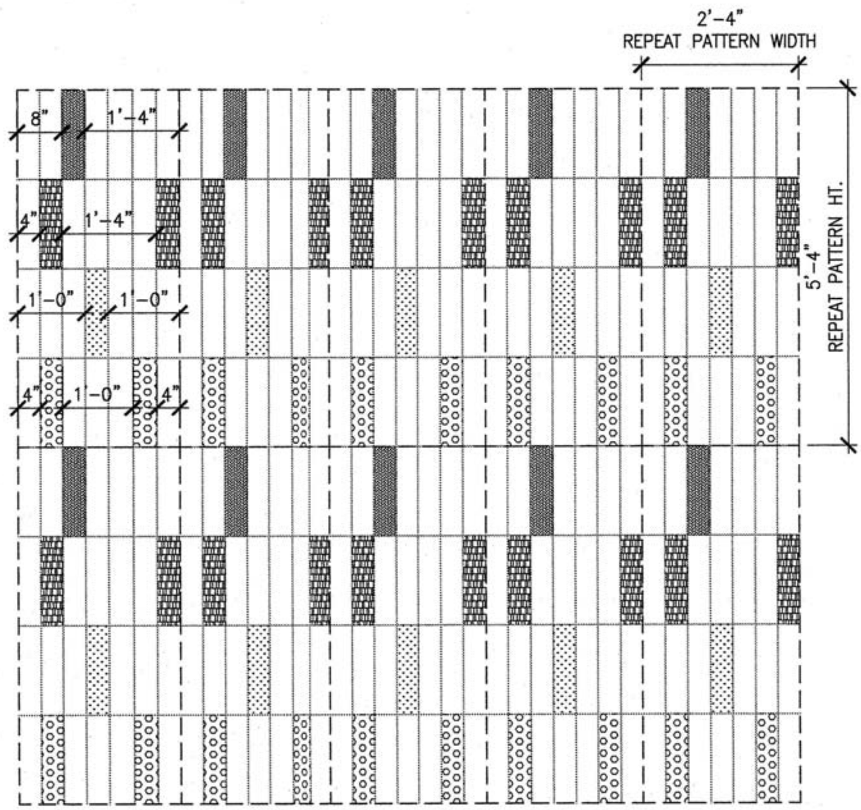


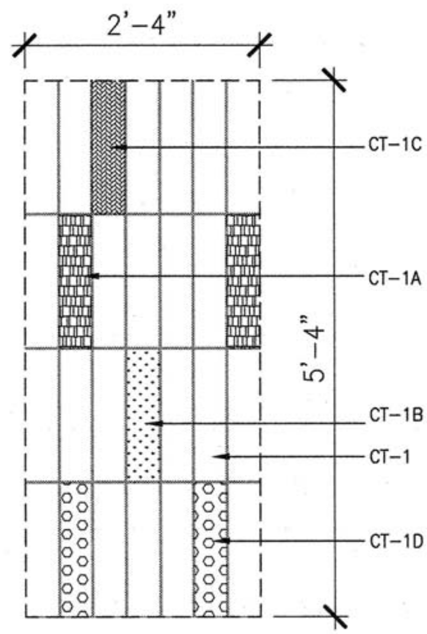
IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

PLANS (CONT'D)

<u>Lower Lobby Ceramic Tile Pattern</u> (N.T.S.)
"Drawing A-402 Detail #1"





IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

LIGHTING DESIGN CRITERIA

Appearance of Space

- This lobby will be the highlight of all the spaces in this building
- The luminaires should have some shade of white as its finish to blend in with the ceiling
- Should have a feeling of spaciousness and grandeur
- Also should have a modern feel with white ceiling and tiles and glass railings

Color Appearance (Color Contrast)

- There needs to be a cool CCT lamp during the day for the lobby mode
- However there needs to be a warm CCT lamp for the gala events held at night
- The power density requirements prevent dual sources to be used
- A cool 3500K CCT lamp will just be used for the whole space because it is mostly used as a lobby anyway

Daylight Integration and Control

- This is a very important criteria seeing how the client desires a LEED certified building
- There are solar shades on the south façade (south wall of the lobby) for the summer so the daylight levels will be variable
- Photo sensors could be installed to detect daylight levels seeing how this project will be certified LEED Gold

Direct Glare

- Will be a problem in winter with low sun angles and double height south facing curtain wall
- Not a problem with luminaires because ceiling height is so high at 21.5'

Flicker and Strobe

- Not a problem with mostly indoor fluorescent lighting

Light Distribution on Surfaces

- Uniformity is desired in the lobby mode during the day
- There will be lounging and light reading in the lobby but other than that, during the day it will mostly be a circulation space
- Non-uniformity during events such as galas at night

Light Distribution on Task Plane

- This is not an important because there no set tasks in this space

Luminances of Room Surfaces

- Luminances will be high due to glossy tile and aluminum panels

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

LIGHTING DESIGN CRITERIA (CONT'D)

Modeling of Faces and Objects

- Need speakers modeled during gala events
- Ceramic tile wall on circular core needs to stand out
  - Very beautiful Italian tile, so the lighting should bring out its exquisiteness

Points of Interests

- Speaker podium during events
- Café area and millwork
- Elevator lobby needs lighting that makes it stands out and to draw visitors for circulation
- Monumental staircase

Reflected Glare

- Could get some reflected glare near with luminaires at curtain wall
- Not significant issue considering the large ceiling height

Shadows

- Will be some shadows from the aluminum columns but uniformity is not required in a lobby

Source/Task/Eye Geometry

- Ceiling height makes this problem not significant

Sparkle/Desirable Reflected Highlights

- The ceramic tile wall should be highlighted as well as the stairs
- The elevator lobby and the café should be highlighted as well for circulation

System Control and Flexibility

- Different scenes and dimming control required
- Programmable scenes for ease of occupant

Illuminance (Horizontal)

- It is somewhat like an office lobby so use criteria C (10 fc)

Illuminance (Vertical)

- The lobby requirement for an office is very minimal so disregard this criteria

ASHRAE 90.1 Requirements

For Lobby → 1.3 W/ft^2

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

DESIGN EXPLANATION

Design Concept

The new lighting design theme for this space is inspired by a circuit board. A circuit board is almost flat with linear strips of light. This concept was translated into this space by providing only recessed and semi recessed lighting in order to have a clean appearance for the ceiling.

This design is intended to achieve a public subjective impression by providing uniform illumination onto the task plane. There will be higher ambient luminance levels in the general lobby area. There will also be peripheral emphasis on only the ceramic tile wall because there is only curtain wall everywhere else. More peripheral lighting would have been desirable, but lighting the curtain wall would have been a waste because of all the glass. Most of the surfaces chosen in the original architectural design are light, so this helps reinforce the public impression. This design is intended for the normal lobby function of the space.

For the gala scene, a private subjective impression is desired. Nonuniform lighting and luminance away from the occupant are important to achieve this impression. There is some peripheral emphasis like the last scene with the ceramic wall being washed. This creates luminance away from the occupant which gives people light to observe away from their general area. Also the café area will be brighter because it will most likely be turned into a bar at these events. The IESNA Handbook recommends 10 fc for dining. The staff at Kean University can adjust this light level with the Lutron controls described in the electrical depth of this space.

As desired in the schematic phase the linear strips of light guide the occupants to their destination. The top row of luminaires guide occupants to the remainder of the first floor. The second row is for guiding to the grand staircase to the Exhibition Space. The third row shows the path to the elevator lobby. The final row closest to the south façade guides occupants

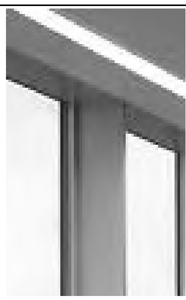
Fixture Mounting

The luminaire chosen for general illumination was a recessed linear fluorescent with staggered lamps to eliminate socket shadows. The wall washers for the ceramic tile wall are semi recessed ceramic metal halide fixtures. The café area has suspended pendant halogen fixtures to attract visitors to purchase food and drink and recessed. The track is recessed into the ceiling to keep the ceiling from having a cluttered appearance.

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

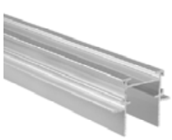
LUMINAIRE SCHEDULE

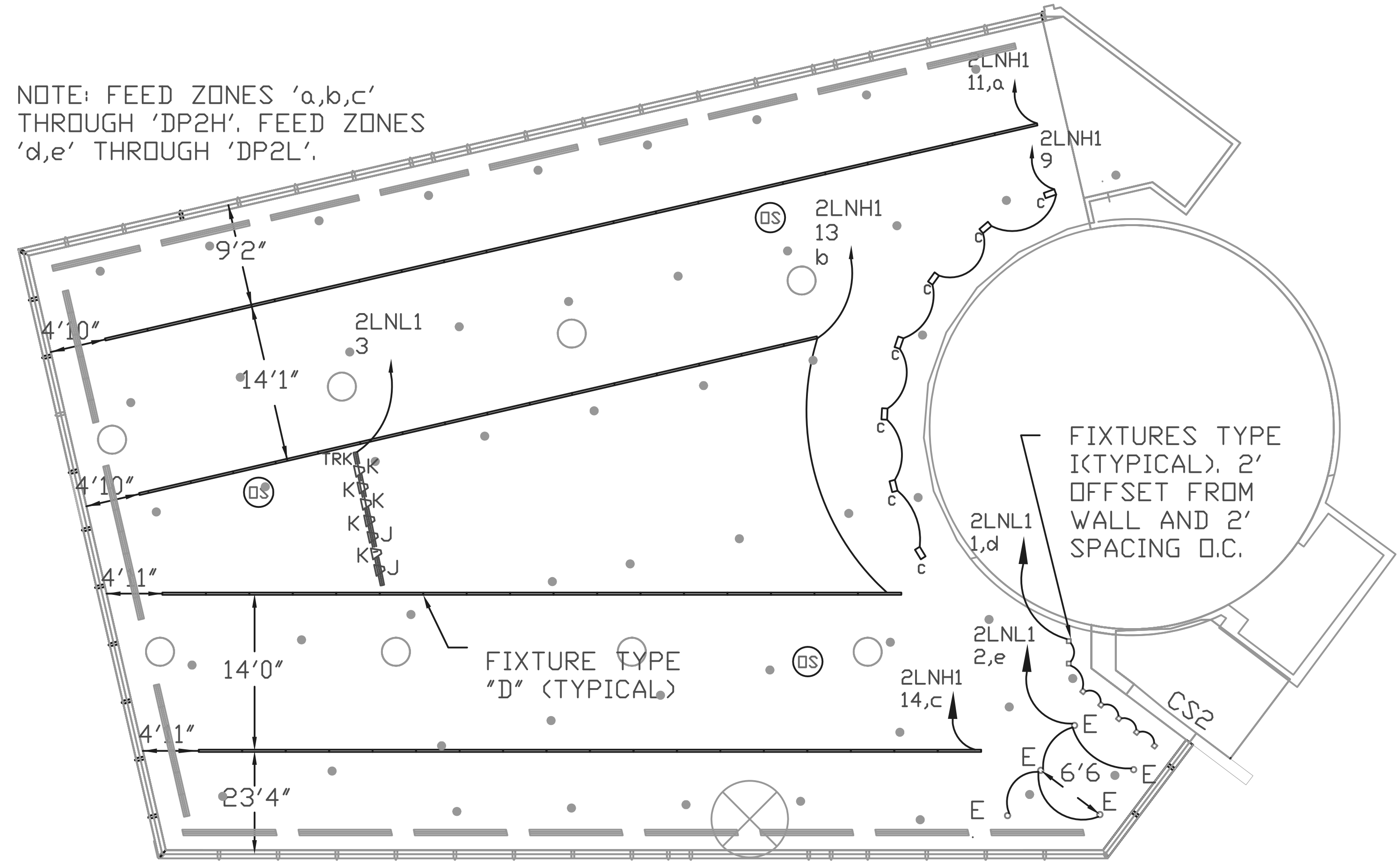
TYPE	IMAGE	MANUFAC-TURER	CATALOG #	DESCRIPTION	LAMP	VOLT-AGE	BALLAST	WATTS
C		ELLIPTIPAR	M-203-035G-T-5-V-00-0	CERAMIC METAL HALIDE WALL WASHER	(MasterColor # CDM-T 35W/830 T6 1CT) 35W 80 CRI 3000K CERAMIC METAL HALIDE	277V	DIMMING INTE-GRAL	43.75
D		SE'LUX	M6R2S-1T5-OD-RC-008-WH-277-DM	RECESSED LINEAR FLUORESCENT	(1) F28T5	277V	DIMMING (10%) LUTRON ECO-10 CAT# ECO-T528-277-1	38.8
E		OMEGA LIGHTING	PIM6-75P30-AL-CS-C	6" HALOGEN DECORATIVE PENDANT WITH 45 DEGREE CUTOFF	(1) GE EDISON 50W PAR20 CATALOG# 14928 – 50PAR20H/FL 25	120V	N/A	50
I		KURT VERSEN	H8451-50W-PAR20-NFL-WHT	4.5" HALOGEN WALL WASHER, RECESSED, WHITE TRIM	(1) GE EDISON 50W PAR20 CATALOG# 14928 – 50PAR20H/FL 25	120V	N/A	50

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

LUMINAIRE SCHEDULE (CONT'D)

TYPE	IMAGE	MANUFAC-TURER	CATALOG #	DESCRIPTION	LAMP	VOLT -AGE	BALLAST	WATTS
J		ZUMTOBEL	VIVOM-39T45G85-S-WHM	METAL HALIDE ACCENT TRACK HEAD	(MasterColor # CDM-T 35W/830 T6 1CT) 35W 80 CRI 3000K CERAMIC METAL HALIDE	120V	N/A	39
K		ZUMTOBEL	VIVOM-39T45G85-F-WHM	4.5" HALOGEN WALL WASHER, RECESSED, WHITE TRIM	(MasterColor # CDM-T 35W/830 T6 1CT) 35W 80 CRI 3000K CERAMIC METAL HALIDE	120V	N/A	39
TRK		ZUMTOBEL	58621WH	1 CIRCUIT FLSU HPROFILE RECESSED TRACK	(MasterColor # CDM-T 35W/830 T6 1CT) 35W 80 CRI 3000K CERAMIC METAL HALIDE	120V	N/A	N/A



AE 482W
JOHN MULHERN

NEW JERSEY CENTER FOR SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION

SUBMITTED FOR PROF. DANNERTH APRIL 7, 2009

LOBBY LIGHTING RCP DIAGRAM

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

CALCULATIONS

Light Loss Factors

Note : All calculations done in accordance with IESNA Handbook pp. 9-20 to 9-23. Assume all ballast factors are 1.0 unless otherwise noted. All initial and mean lumens were referenced from Osram Sylvania's Lamp and Ballast Catalog.

C

- Category V: Opaque unapertured top enclosure, translucent unapertured bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = $e^{(-At^B)}$ = $e^{[-(0.078)(1\ year)^{0.53}]}$
- LDD=0.925
- Category V, very clean → RSDD =0.93
- LLD = 3150 Mean lumens/3300 Initial Lumens = 0.95
- PF = 0.9
- Total LLF = (0.925)(0.94)(0.95)(1.0)(0.9) = 0.743

D

- Category V: Opaque unapertured top enclosure, translucent unapertured bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = $e^{(-At^B)}$ = $e^{[-(0.078)(1\ year)^{0.53}]}$
- LDD=0.925
- Category V, very clean → RSDD =0.93
- LLD = 2594 Mean lumens/2730 Initial Lumens = 0.95
- PF = 0.95
- Total LLF = (0.902)(0.925)(0.93)(0.95)(1.0)(0.95) = 0.7

E

- Category IV: Opaque unapertured top enclosure, no bottom enclosure
- Very Clean environment → B=0.72, A=0.070
- Assume cleaning cycle is 12 months (1 year)
- LDD = $e^{(-At^B)}$ = $e^{[-(0.070)(1\ year)^{0.72}]}$
- LDD=0.932
- Category IV, very clean → RSDD =0.94
- LLD = 440 Mean lumens/570 Initial Lumens = 0.77
- Total LLF = (0.932)(0.94)(0.77) = 0.674

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

CALCULATIONS

Light Loss Factors (cont'd)

I

- Category V: Opaque unapertured top enclosure, translucent unapertured bottom
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = $e^{(-At^B)} = e^{[-(0.078)(1 \text{ year})^{0.53})}$
- LDD=0.925
- Category V, very clean → RSDD =0.94
- LLD = 440 Mean lumens/570 Initial Lumens = 0.77
- Total LLF = (0.925)(0.94)(0.77) = 0.670

J

- Category V: Opaque unapertured top enclosure, no bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = $e^{(-At^B)} = e^{[-(0.078)(1 \text{ year})^{0.53})}$
- LDD=0.925
- Category V, very clean → RSDD =0.94
- LLD = 3150 Mean lumens/3300 Initial Lumens = 0.95
- PF = 0.9
- Total LLF = (0.925)(0.94)(0.95)(1.0)(0.9) = 0.743

K

- Category V: Opaque unapertured top enclosure, no bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = $e^{(-At^B)} = e^{[-(0.078)(1 \text{ year})^{0.53})}$
- LDD=0.925
- Category V, very clean → RSDD =0.94
- LLD = 3150 Mean lumens/3300 Initial Lumens = 0.95
- PF = 0.9
- Total LLF = (0.925)(0.94)(0.95)(1.0)(0.9) = 0.743

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

CALCULATIONS (CONT'D)

Power Density

Note : All calculations done in accordance with IESNA Handbook pp. 9-20 to 9-23 and Chapter 9 of AHSRAE Standard 90.1-2007. Assume all ballast factor are 1.0 unless otherwise noted.

C

- 7 Luminaires
- Ballast input current of 0.16 A for
- 277 V x 0.16A x 7 luminaires = 310 W

D

- 72 Luminaires
- Ballast input current of 0.14 A for
- 277 V x 0.14 x 72 luminaires = 2792 W

E

- 5 Luminaires
- 50W per fixture
- 50W x 5 luminaires = 250 W

I

- 6 Luminaires
- 50W per fixture
- 50W x 6 luminaires = 300 W

J

- 5 Luminaires
- 39W per fixture
- 39W x 5 luminaires = 195 W

K

- 2 Luminaires
- 39W per fixture
- 39W x 2 luminaires = 78 W
- Room Area = 5498 SF
- 1.3 W/SF for "Lobby Space" requirement ASHRAE Std. 90.1
- 3925 TOTALWATTS /5498 SF = 0.714 W/SF
- **0.714 W/SF < 1.3 W/SF ASHRAE STD. 90.1 REQUIREMENT**

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

LOBBY SCENE RESULTS

In the lobby scene, there is a very uniform distribution on the floor which was a major criteria. The recommended footcandle levels were achieved as recommended by the IES Handbook. The luminaires act as paths for the occupants leading the occupants to four different paths of circulation. One row leads to the café, another leads to the elevator core, the third leads to the grand staircase, and the fourth luminaires strip leads to the rest of the first floor. There is some peripheral emphasis with the ceramic tile wall being washed by a semi recessed metal halide fixture. Regardless of the scene this architectural element is the focal point of the space. The light guides people up the stairs to see what else the building has in store for them.

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
zCeramicBig_9_Wallwash	Illuminance	Fc	19.38	49.3	9.6	2.02	5.14
CalcPts	Illuminance	Fc	12.98	18.1	4.1	3.17	4.41

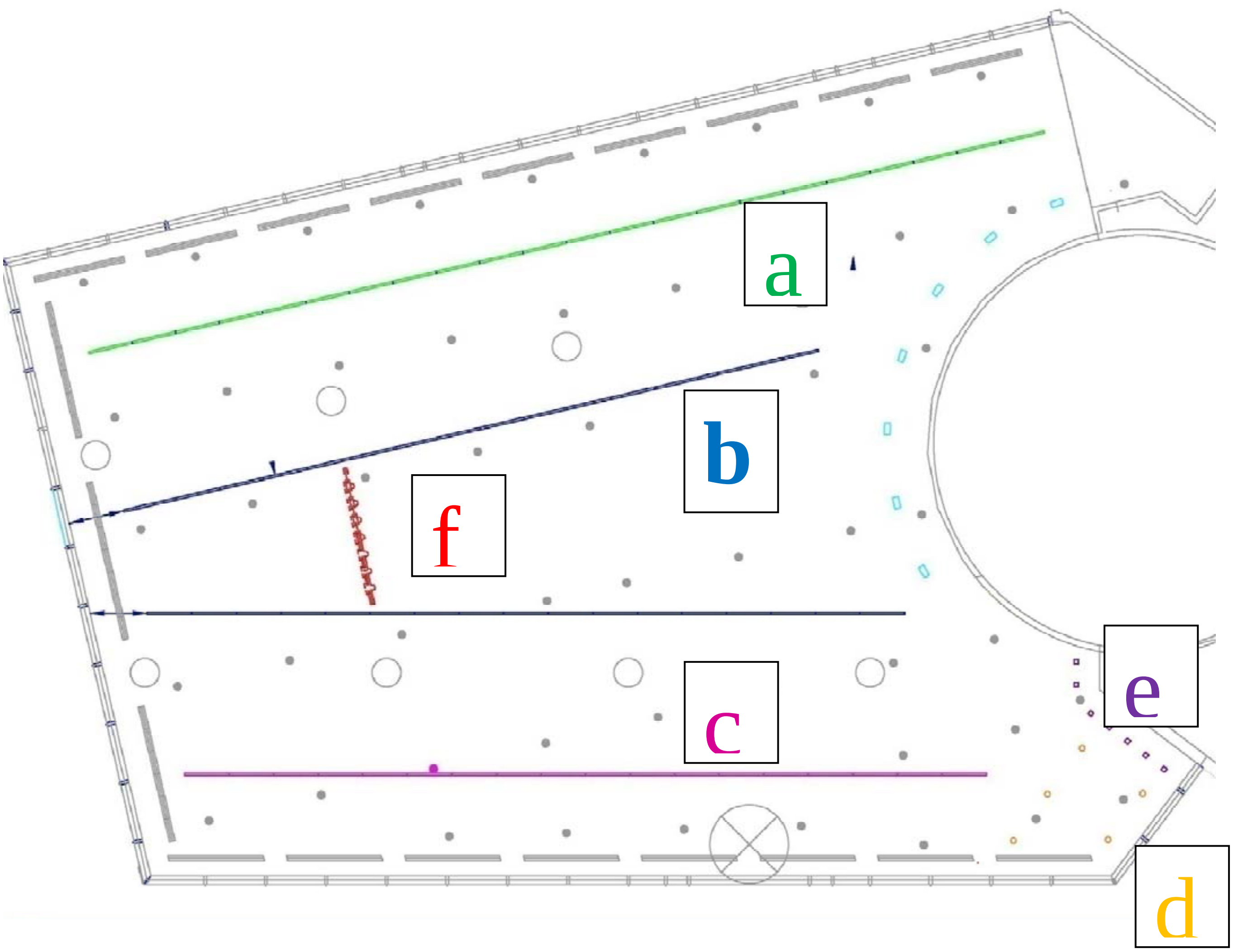
<u>FIG. L-1</u>
CALCULATION SUMMARY LOBBY SCENE

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

LOBBY SCENE RESULTS (CONT'D)

LOBBY SCENE DIMMING LEVELS						
	Zone "a" - North Row of 'D' Fixtures	Zone "b" - Two Middle Rows of 'D' Fixtures	Zone "c" - South Row of 'D' Fixtures	Zone "d" - Café Wall Washers	Zone "e" - Pendant Fixtures	Zone "f" - Track
Dimming Level	60%	60%	60%	100%	100%	OFF



IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

LOBBY SCENE RESULTS (CONT'D)

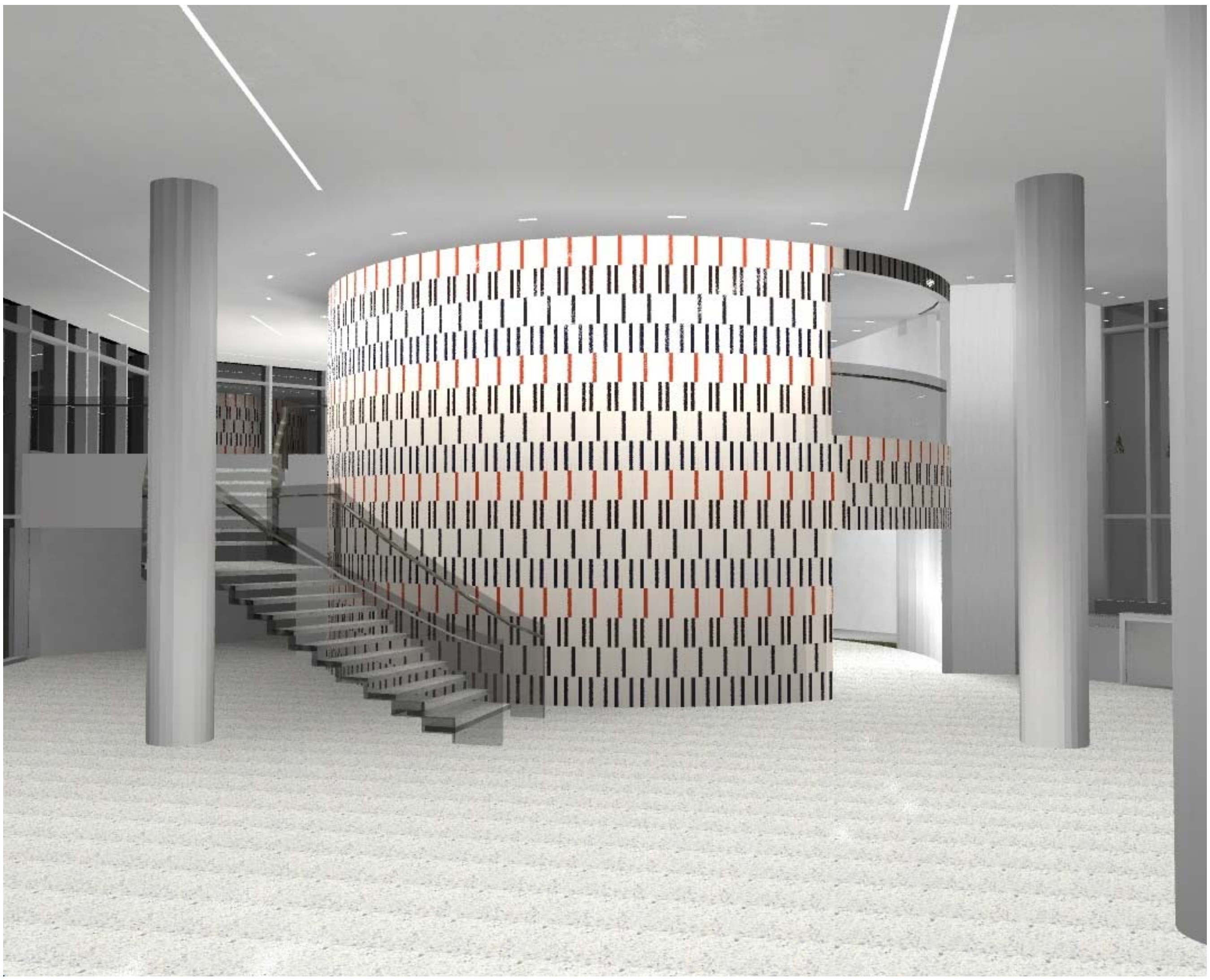


FIG. L-2

EAST PERSPECTIVE RENDERING OF LOWER LOBBY

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

LOBBY SCENE RESULTS (CONT'D)

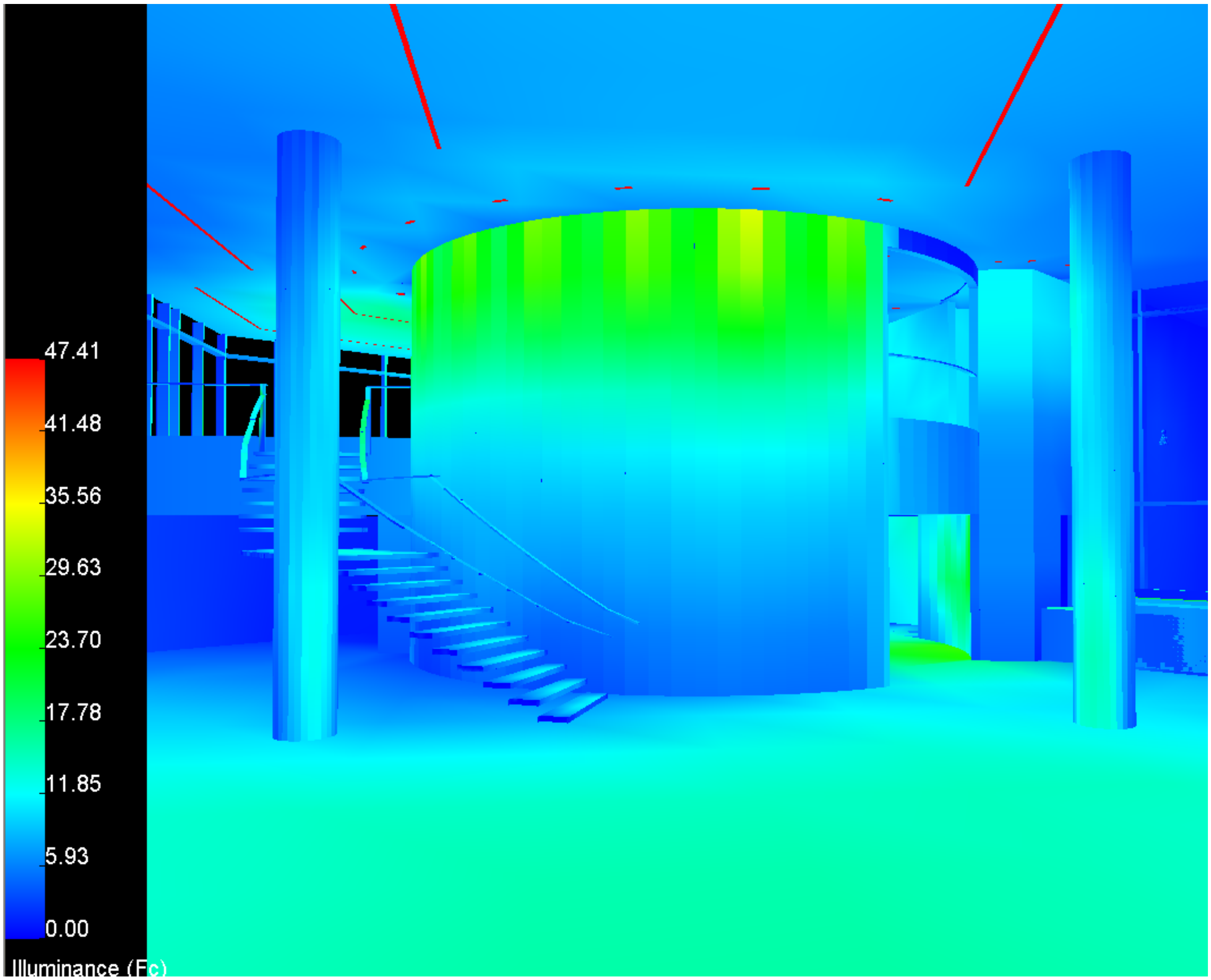


FIG. L-3
EAST PERSPECTIVE ILLUMINANCE PSEUDOCOLOR OF LOBBY

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

GALA SCENE RESULTS

The gala scene turned out to work very well. The track fixtures are useful for a grand table during one of the gala events. The tracks provide an illuminance ratio of approximately 10:1 if necessary. The linear fluorescent fixtures were dimmed to provide a level of 7.5 fc. There will be tables at these galas events which will provide some lighting such as a candle. The IES recommends 10 fc for dining so the table light will help reach the criteria.

The ceramic tile wall washers provide luminance away from the occupant which enforces the private impression. The ceramic tile wall is the focal point of the space and should be brighter than any other surface. The café will most likely turn into a bar during these events, so the light on the back wall and its pendant fixtures will draw people to get drinks.

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
zCeramicBig_9_Wallwash	Illuminance	Fc	12.44	34.8	4.6	2.70	7.57
CalcPts	Illuminance	Fc	7.50	86.3	2.6	2.88	33.19
zSTONE 2 Lower	Illuminance	Fc	14.14	17.8	6.8	2.08	2.62
Back Counter_Back Counter	Illuminance	Fc	12.94	17.1	5.4	2.40	3.17

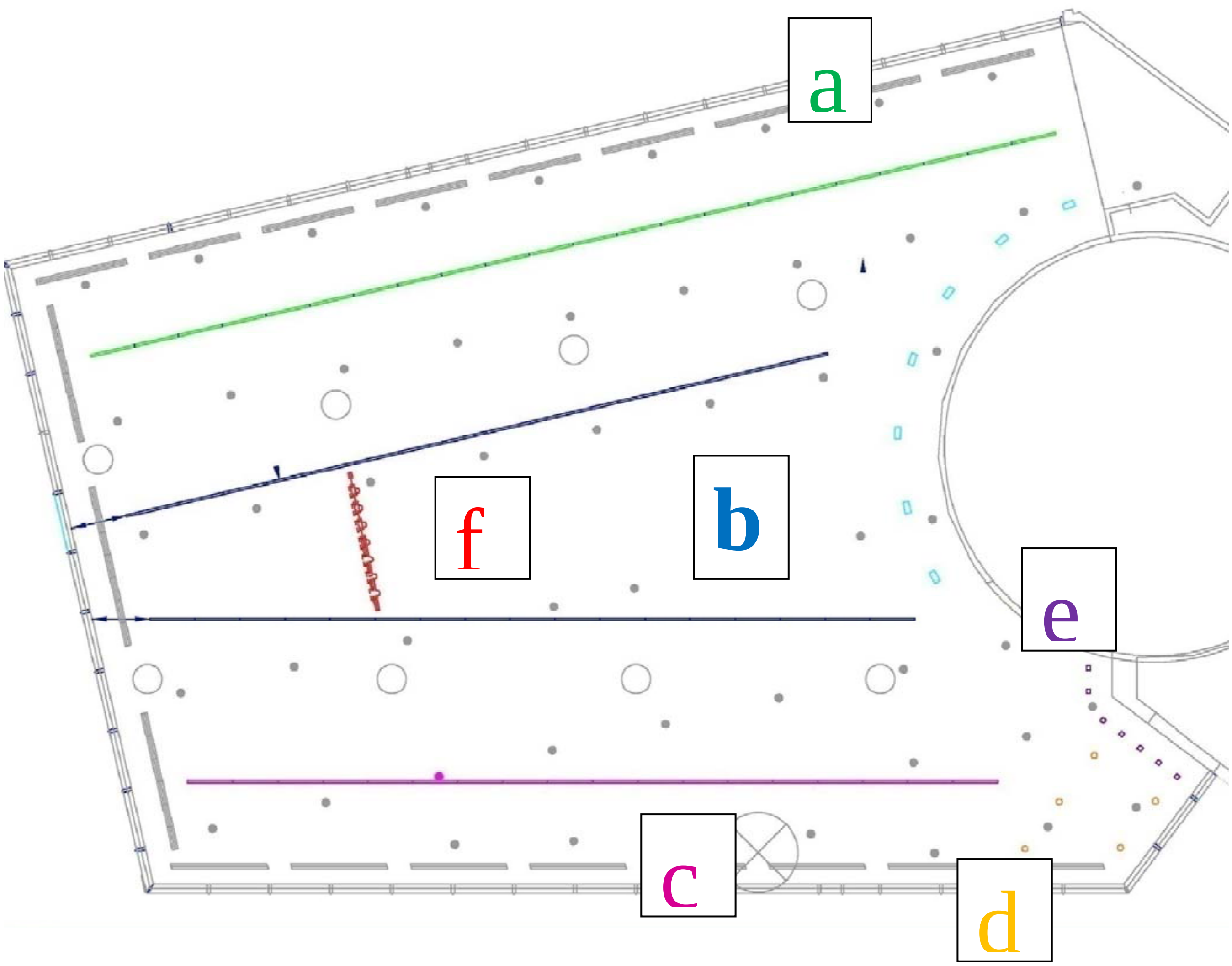
FIG. L-4
CALCULATION SUMMARY OF GALA SCENE

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

GALA SCENE RESULTS (CONT'D)

GALA SCENE DIMMING LEVELS						
	Zone "a" - North Row of 'D' Fixtures	Zone "b" - Two Middle Rows of 'D' Fixtures	Zone "c" - South Row of 'D' Fixtures	Zone "d" - Café Wall Washers	Zone "e" - Pendant Fixtures	Zone "f" - Track Fixtures
Dimming Level	20%	20%	20%	100%	100%	100%



IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

GALA SCENE RESULTS (CONT'D)

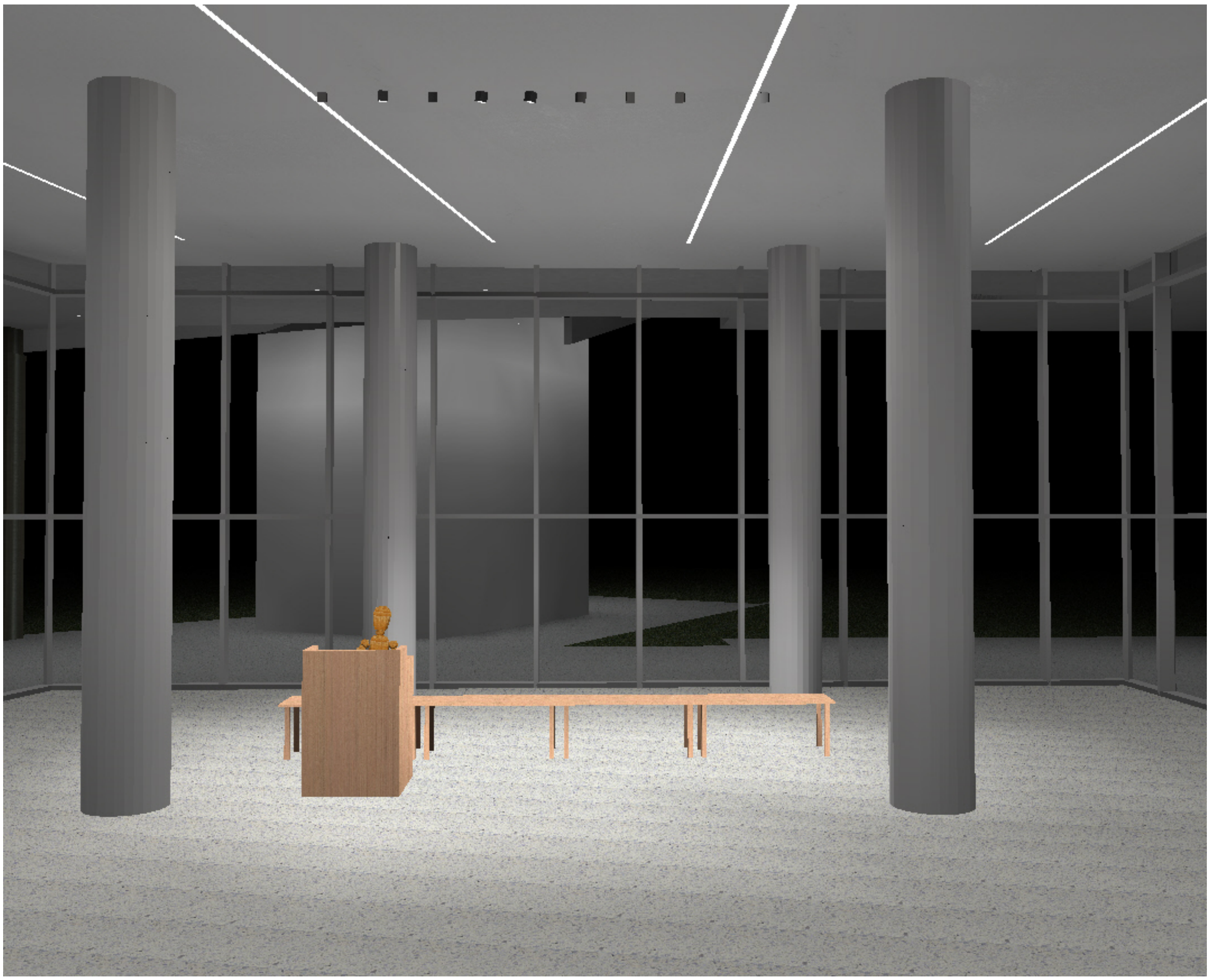
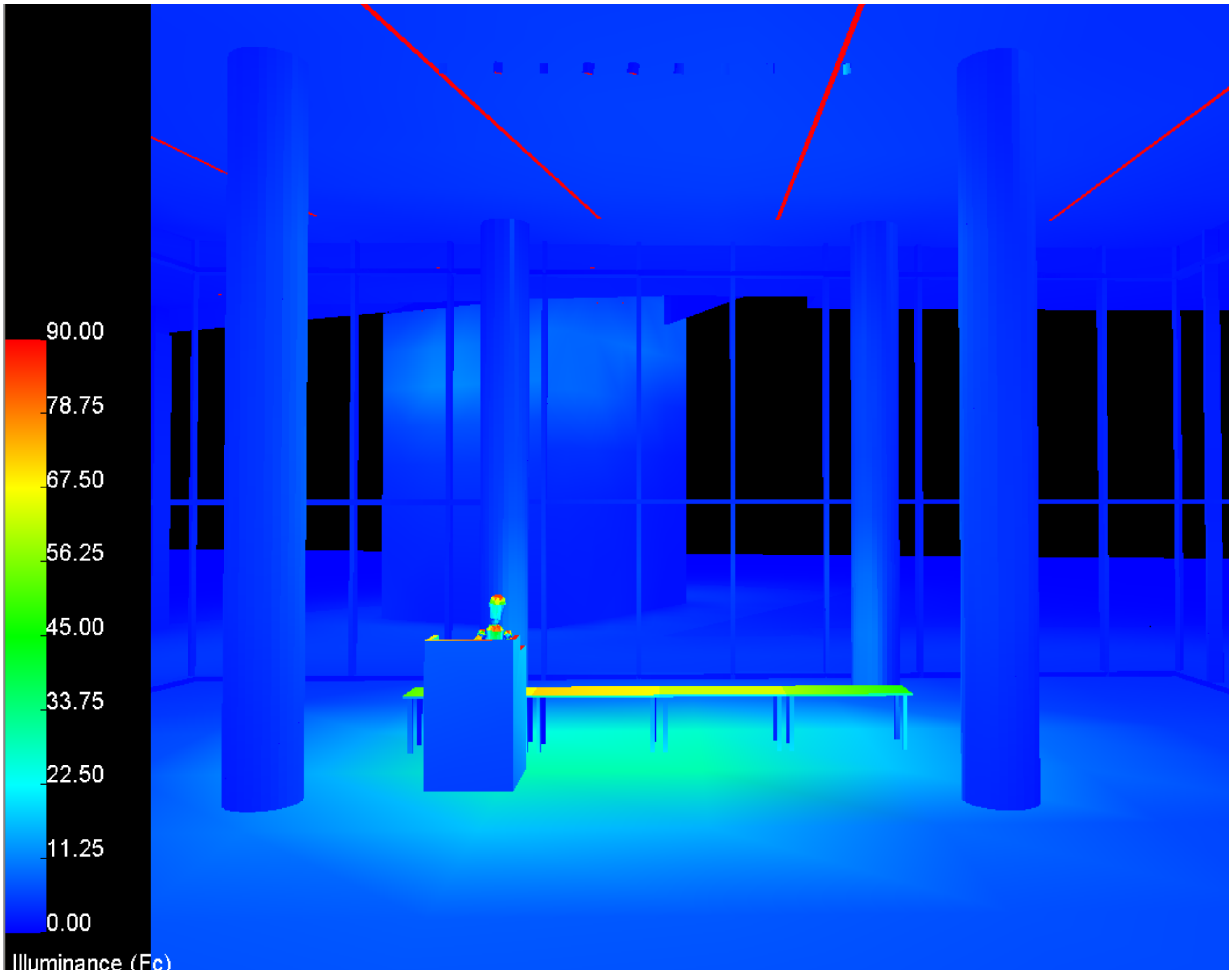


FIG. L-5
EAST PERSPECTIVE RENDERING

IV. LIGHTING DEPTH

C.) LOWER LOBBY REDESIGN

GALA SCENE RESULTS (CONT'D)



<u>FIG. L-6</u>
EAST PERSPECTIVE ILLUMINANCE PSEUDOCOLOR OF LOBBY

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

EXISTING SPACE CONDITIONS

Description

The outdoor space is outside of the main entrance on the south side of the building. There is a concrete sidewalk at the exit of the building. It splits similar to a shape of a wishbone in plan. The two paths converge and lead to the building. There is grasscrete along the edge of sidewalk, but not for the entire run. There are only a few trees inside the wishbone shape. There is also low vegetation along the brick wall adjacent to the auditorium. Otherwise the space is very open. The portico area will also be in the scope of this space.

Tasks

There will not be many tasks for the outdoors. Eventually there will be benches of some sort at which people congregate. The space is generally for circulation in or out of the building. It is the main entrance to the elegant lobby, so it should stand out more than other paths.

Materials

Most of this space is open grass and some concrete for sidewalks. Grasscrete is used along the edges of the path so car tires do not destroy the grass. Grasscrete is like a honeycomb of concrete with grass poking through. It provides a transition from grass to concrete as well. The portico area has concrete floors, and it is covered by an outdoor gypsum wall board ceiling. The portico surrounds most of the lobby space.

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

LIGHTING DESIGN CRITERIA

Appearance of Space

- This is a wide open green space with very little trees
- At night the building will stand out having no other buildings in close proximity
  - Building will glow from inside with all the curtain wall

Color Appearance (Color Contrast)

- High Pressure Sodium lamps make spaces seem too gloomy and drown out all the potential for colors to show up at night
- CCT should be cool to simulate daylight at night
- The path will have contrast because the open grass does not have light poles installed there

Daylight Integration and Control

- There is no need for this because they lights will be only for night and on a time clock

Direct Glare

- Can be a nuisance to people walking towards the building
- Keep vertical aiming angle at 45 degrees or below

Flicker and Strobe

- Could be a problem in extreme cold which happens in winter in the Northeast
- Only a problem at startup however and lights turn on before it turns completely dark

Light Distribution on Surfaces

- Uniformity would have a better aesthetic but will be difficult to achieve with power density criteria
- Uniformity if possible though in portico area

Luminances of Space Surfaces

- This is a residential/rural setting so the luminance cannot be too much larger relative to the background which is very dark
- Could possibly increase luminance closer to the building because the building is all curtain wall, so it will be a brighter background than the night sky

Modeling of Faces and Objects

- Not important

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

LIGHTING DESIGN CRITERIA (CONT'D)

Points of Interests

- Glowing building in the distance
- Aluminum panel stairwell corridor wall
- Very irregular shape and an architectural statement
- Not many other points of interest cause it is an open field

Reflected Glare

- Not a problem with concrete pathways and grass

Shadows

- No problems with shadows because path is open

Source/Task/Eye Geometry

- Luminaires should not have steep vertical angles for glare reasons

Sparkle/Desirable Reflected Highlights

- None are really necessary
- Path is highlighted because it is the only thing lit outside

System Control and Flexibility

- Time clock for when night time occurs

Illuminance (Horizontal)

- Assume its outdoors, a garden, and a path away from the building
    - IESNA then recommends 1 fc for this pathway

Illuminance (Vertical)

- Vertical Illuminance for security reasons in portico area
    - Will help camera identify person trying to break in if building is closed

ASHRAE 90.1 Requirements

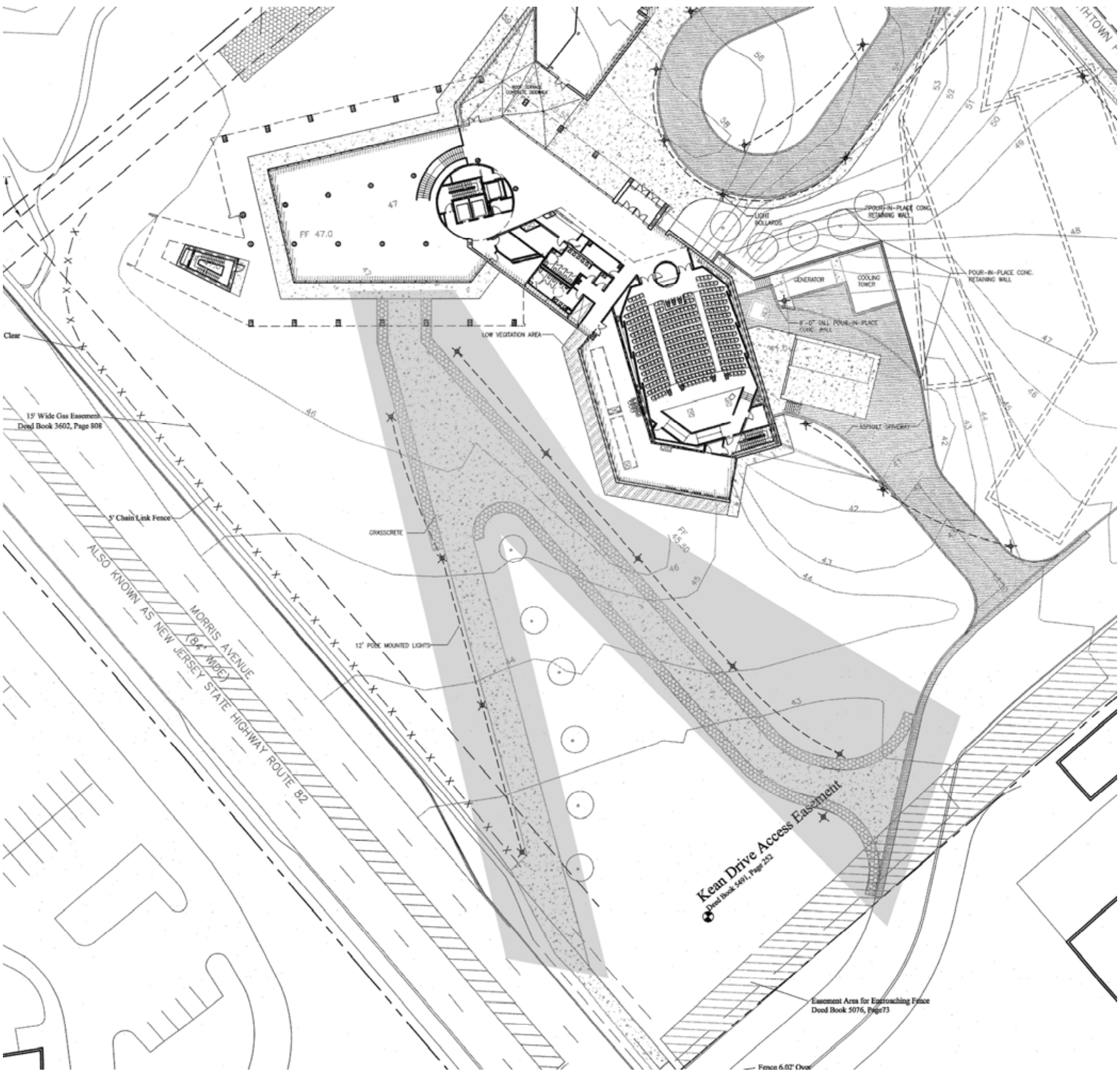
- For lamps greater than 100W, they must have efficacy of 60lumens/watt or better as required by ASHRAE
- Pathway outside is greater than 10 feet wide
    - ASHRAE requires 0.2 W/ft^2 for walkways of 10 feet or wider

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

PLANS

<u>Outdoor Site Plan</u> (N.T.S.)
"Drawing A-000"



IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

DESIGN EXPLANATION

Design Concept

The bollard style fixture was used to reinforce the theme of the “circuit board”. These luminaires provide a linear outline along the path to guide people to the building. The new lighting will incorporate luminaires that reflect the architectural style of this building. The luminaire chosen is a bollard fixture manufactured by Bega. This luminaire is a small bollard unlike the old design with large pole mounted fixtures. The silver finish complements the mullions of curtain wall around the building. A time clock will turn on the lights at a set time at night.

The staggered layout as suggested in the schematic design did not work out. The distribution of light on the pathway was aesthetically unpleasing. The fixtures were placed across from each other at a 10’ typical spacing along the pathway.

The portico area continues the recessed theme with recessed metal halide down lights for general illuminance and metal halide wall washers to accent the architectural statement of the west stairwell corridor walls. An attempt was made to uplight the columns, but since they were flush against the façade, spill light caused unsightly reflections farther up the building. The down lights will back light the columns giving the portico depth from a distance while providing illuminance for security as well.

Fixture Mounting

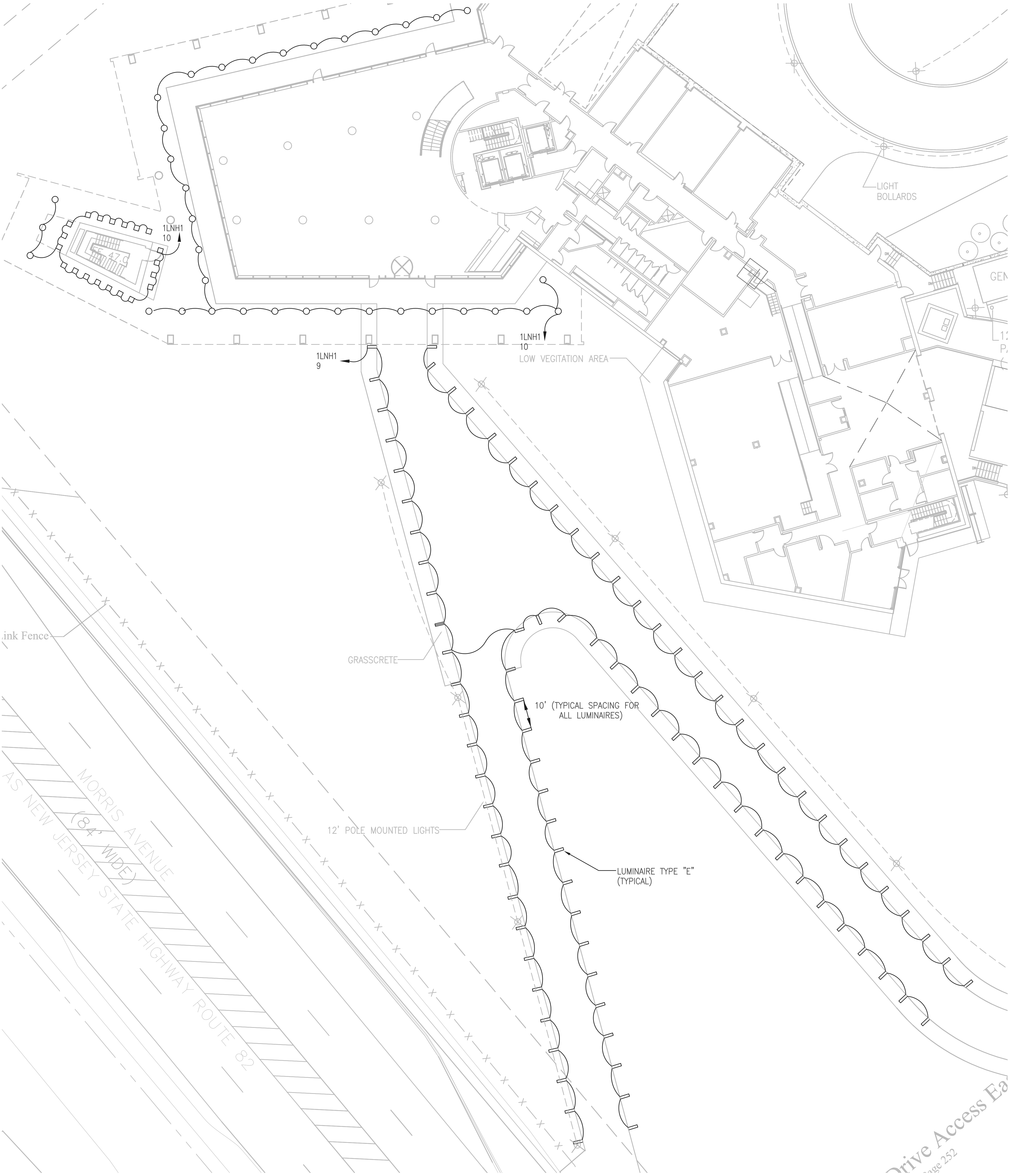
The fixture will be anchored into the ground. The grasscrete surface will require holes in order to anchor the luminaires. The luminaires will be placed on the edge of the grasscrete right before the concrete pathway. The other two fixtures will be recessed into outdoor gypsum wall board ceiling.

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

LUMINAIRE SCHEDULE

TYPE	IMAGE	MANUFAC-TURER	CATALOG #	DESCRIPTION	LAMP	VOLT-AGE	BALLAST	WATTS
F		BEGA	8524 MH	CERAMIC METAL HALIDE BOLLARD FIXTURE, EXTRUDED ALUMINUM FINISH W/ INTERNAL ASYMMETRICAL REFLECTOR	(1) METAL HALIDE T4 20W, G8.5 BASE, 3000K	277V	ADVANCE #RMH-20-E	25
G		COOPER	P406TAT-MH4CMH-20T6E-EL4WW-MW	IRIS® 4" RECESSED WALL WASH LUMINAIRE WITH GALVANIZED STEEL HOUSING, WITH SPECULAR ALUMINUM KICKER REFLECTOR	(1) METAL HALIDE 20W T6, G12 BAS, 3000K	277V	POWER SELECT INC. MODEL # PS10B20K	25
H		ERCO	81040.000	LIGHT SCOUT MODEL, METAL HALIDE EXTERIOR DOWNLIGHT CAST ALUMINUM	(1) METAL HALIDE 20W HIT-TC-CE, 3000K	277V	POWER SELECT INC. MODEL # PS10B20K	25



1LNH1
10
1LNH1
10
1LNH1
9
LOW VEGITATION AREA
LIGHT
BOLLARDS
ink Fence
GRASSCRETE
10' (TYPICAL SPACING FOR
ALL LUMINAIRES)
12' POLE MOUNTED LIGHTS
LUMINAIRE TYPE "E"
(TYPICAL)
MORRIS AVENUE
(84' WIDE)
AS NEW JERSEY STATE HIGHWAY ROUTE 82
Drive Access Ea

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

CALCULATIONS

Light Loss Factors

Note : All calculations done in accordance with IESNA Handbook pp. 9-20 to 9-23 and Chapter 9 of AHSRAE Standard 90.1-2007. Assume all ballast factors are 1.0 unless otherwise noted.

F

- Category VI: Opaque unapertured top enclosure, Opaque unapertured bottom enclosure
- Medium environment → B=0.88, A=0.218
- Assume cleaning cycle is 6 months (0.5 year)
- LDD = e^(-At^{B}) = e^[-(0.218)(0.5 year)$^{0.88}$)
- LDD=0.888
- RSDD → Outdoors
- LLD = 1275 Mean lumens/1700 Initial Lumens = 0.75
- BF not listed on cut sheet → Assume BF = 1.0
- PF = 0.96
- Total LLF = (0.75)(0.888)(0.96)(1.0) = 0.64

G

- Category V: Opaque unapertured top enclosure, transparent unapertured bottom enclosure
- Medium environment → B=0.53, A=0.19
- Assume cleaning cycle is 6 months (0.5 year)
- LDD = e^(-At^{B}) = e^[-(0.218)(0.5 year)$^{0.53}$)
- LDD=0.86
- RSDD → Outdoors
- LLD = 1200 Mean lumens/1600 Initial Lumens = 0.8
- BF not listed on cut sheet → Assume BF = 1.0
- PF = 0.96
- Total LLF = (0.86)(0.8)(0.96)(1.0) = 0.66

H

- Category V: Opaque unapertured top enclosure, transparent unapertured bottom enclosure
- Medium environment → B=0.53, A=0.19
- Assume cleaning cycle is 6 months (0.5 year)
- LDD = e^(-At^{B}) = e^[-(0.218)(0.5 year)$^{0.53}$)
- LDD=0.86
- RSDD → Outdoors
- LLD = 1275 Mean lumens/1700 Initial Lumens = 0.75
- BF not listed on cut sheet → Assume BF = 1.0
- PF = 0.96
- Total LLF = (0.86)(0.75)(0.96)(1.0) = 0.62

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

CALCULATIONS (CONT'D)

Power Density

Note : All calculations done in accordance with IESNA Handbook pp. 9-20 to 9-23 and Chapter 9 of AHSRAE Standard 90.1-2007. Assume all ballast factor are 1.0 unless otherwise noted.

F

- 92 Luminaires
- Ballast input current of 0.09A for
- 277 V x 0.09A x 92 luminaires = 2294 W

G

- 20 Luminaires
- Ballast input current of 0.09A for
- 277 V x 0.09A x 20 luminaires = 499 W

H

- 35 Luminaires
- Ballast input current of 0.09A for
- 277 V x 0.09A x 35 luminaires = 873 W

South Façade Outdoor Walkway

- Area ≈ 15000 SF
- 0.2 W/SF for "Walkway" requirement ASHRAE Std. 90.1
- (92) 'F' Luminaires
- 2294TOTALWATTS /15000 SF
- **0.153 W/SF < 0.2 W/SF ASHRAE STD. 90.1 REQUIREMENT**

Portico Area

- Area ≈ 8550SF
- 1.25 W/SF for "Canopies and Overhangs"
- (35)'H' Fixtures
- 873 WATTS /8550 SF
- **0.102 W/SF < 0.2 W/SF ASHRAE STD. 90.1 REQUIREMENT**

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

CALCULATIONS (CONT'D)

Power Density (cont'd)

South Wall (West Stairwell Corridor)

- Area ≈ 738SF
- 0.2 W/SF for Building Facade
- (7)'H' Fixtures
- 277 V x 0.09A x 7 luminaires = 174.5 W
- 174.5 WATTS /738 SF
- **0.236 W/SF > 0.2 W/SF ASHRAE STD. 90.1 REQUIREMENT**
- **DOES NOT MEET ASHRAE CRITERIA**

West Wall (West Stairwell Corridor)

- Area ≈ 381 SF
- 0.2 W/SF for Building Facade
- (3)'H' Fixtures
- 277 V x 0.09A x 3 luminaires = 74.5 W
- 174.5 WATTS /381 SF
- **0.196 W/SF < 0.2 W/SF ASHRAE STD. 90.1 REQUIREMENT**

NorthWall (West Stairwell Corridor)

- Area ≈ 672 SF
- 0.2 W/SF for Building Facade
- (6)'H' Fixtures
- 277 V x 0.09A x 6 luminaires = 150 W
- 150 WATTS /672 SF
- **0.223 W/SF > 0.2 W/SF ASHRAE STD. 90.1 REQUIREMENT**
- **DOES NOT MEET ASHRAE CRITERIA**

East Wall (West Stairwell Corridor)

- Area ≈ 381 SF
- 0.2 W/SF for Building Facade
- (4)'H' Fixtures
- 277 V x 0.09A x 4 luminaires = 100 W
- **0.262 W/SF > 0.2 W/SF ASHRAE STD. 90.1 REQUIREMENT**
- **DOES NOT MEET ASHRAE CRITERIA**

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

RESULTS

The outdoor design met all the power criteria specified. The bollard fixtures guide people to the building portico. The building portico has a lower illuminance than the indoors to reinforce the architects transparency theme with all the curtain wall. The interior portico is lit with a 20W metal halide down light that provides just enough light for outdoors and for security identification with cameras.

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
Portico_1_Portico	Illuminance	Fc	2.82	5.5	0.4	7.05	13.75
Stairwell Wall_Stairwell Wall_1	Illuminance	Fc	3.04	11.2	0.0	N.A.	N.A.
CalcPts 1	Illuminance	Fc	0.20	0.5	0.0	N.A.	N.A.
Walkway	Illuminance	Fc	0.02	0.9	0.0	N.A.	N.A.

FIG. O-1
CALCULATION SUMMARY OF OUTDOOR SPACE (NO INTERIOR LIGHTS)

IV. LIGHTING DEPTH

D.) OUTDOOR SPACE REDESIGN

RESULTS (CONT'D)

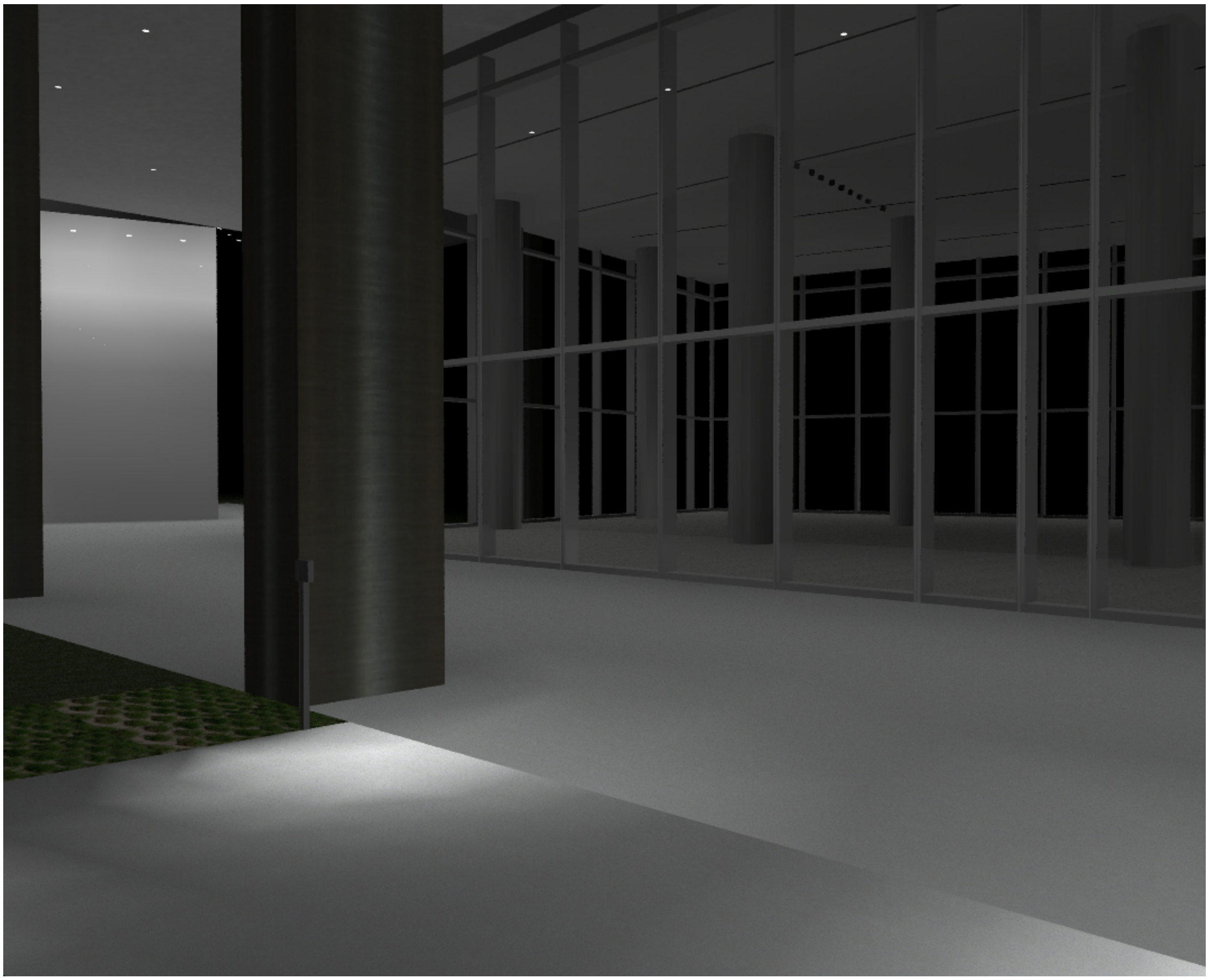


FIG. O-2
SOUTH PERSPECTIVE OF LOWER LOBBY AT SOUTH FAÇADE (NO INTERIOR LIGHTS)

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

EXISTING SPACE CONDITIONS

Description

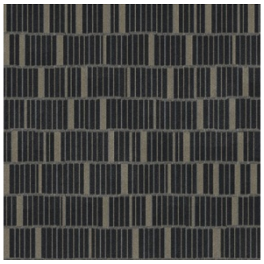
This lecture hall has approximately 280 students with fold out desks. The ceiling has multiple slopes with heights ranging from 8', 10', 11.5', 12', and 12.5'. It has a jagged shape when viewed in section. There are three sections of seats with two aisles. There is a stage area where most likely a teacher will have a desk onto which he or she will place his belongings. The walls are made of acoustic material for sound absorption to prevent echoes. The walls have a jagged shape in plan for acoustic reflections. The floors are made of carpet with a rubber base underneath. There is also a projector room which will house the projector and controls for presentations.

Tasks

There are multiple tasks in this auditorium building. First and foremost there are many desks. There will be approximately 280 students reading and writing in this classroom during lectures. This is an important task to consider for lighting design criteria. The projection screen is another important task for the students. There must not be a lot of glare. The professor also has to read his own lecture notes on his podium/desk and talk to the class on a microphone system.

Floor

The stage floor is composed of wood flooring WS-1. It is maple custom grade strip flooring. The rest of the auditorium flooring is covered in carpet CPT-1. The floor is covered with 3'x3' carpet tiles in the color 708 stone. It is tufted and textured loop pile carpet made of nylon.



3' x 3' CARPET TILES

Ceiling

The ceiling is mostly 2'x6' glass fiber reinforced gypsum panel. These panels have perforations for acoustical purposes. The ceiling has multiple slopes with heights ranging from 8', 10', 11.5', 12', and 12.5'. It has a jagged shape when viewed in section.

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

EXISTING SPACE CONDITIONS (CONT'D)

Walls

Most of the walls in the auditorium are finished with painted white gypsum board. There are 4 different types of TEXAA acoustic panel for sound absorption. A large amount of this material is used in the rear of the room to control the sound reverberation time from the speaker system.

ACOUSTIC PANEL

The curved projection room wall has the exact same ceramic tile pattern as mentioned in the "Walls" section of the Lower Lobby on page 31 of this report.

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

LIGHTING DESIGN CRITERIA

Appearance of Space

- This is a large lecture hall so it should have a feeling of spaciousness
- The luminaires should be some sort of white finish to blend in with a lot of the gypsum wall board ceiling
- Where there is exposed ceiling, the luminaires finish should be darker to blend in because the ceiling plenum is obviously not illuminated

Color Appearance (Color Contrast)

- There needs to be 2 different CCT lamps for this space for different functions
- There is a general lecture mode where 3500 K CCT will be used
- There is contrast between the TEXXA acoustical covering and the gypsum wall board
- There is also contrast between the metal fascia and these materials

Daylight Integration and Control

- There are no windows in this lecture hall

Direct Glare

- There is a concern at the projector screen for the students visibility
- There should not be a lot of spill light near the projector which will cause too high of a vertical illuminance hindering the students' ability to see

Flicker and Strobe

- Not a problem with mostly indoor fluorescent lighting

Light Distribution on Surfaces

- Uniformity is desired for reading and writing which will be the main tasks
- Uniform vertical illuminance on the projector as well
- Walls do not have to be uniform

Light Distribution on Task Plane

- This should be uniform for reading and writing

Luminances of Room Surfaces

- The projector screen should have a lower illuminance compared to the other walls so the images are clear

Modeling of Faces and Objects

- Professor needs to be modeled at his desk for presentations
- Curved projector room wall with ceramic tile should be washed

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

LIGHTING DESIGN CRITERIA(CONT'D)

Points of Interests

- Projector screen during presentations
- Teacher and is desk are points of interest when not in presentation mode
- Curved ceramic tile wall is an interesting sight when students exit the auditorium

Reflected Glare

- Not significant issue considering the large ceiling height

Shadows

- No problems with shadows

Source/Task/Eye Geometry

- Luminaires should not have steep vertical angles
    - This will cause the screen to be illuminated to high
    - Has the potential for glare with the students

Sparkle/Desirable Reflected Highlights

- The ceramic tile wall should be highlighted

System Control and Flexibility

- One mode for general lecture
- Another mode for presentations on the large projector screen

Illuminance (Horizontal)

- IESNA recommends category C for an assembly auditorium (10 fc)
    - This will work for presentation mode
- For general lecture and note taking with young students who have good eyesight, 30 fc should suffice

Illuminance (Vertical)

- IESNA recommends category A for vertical illuminance (5 fc)
- This is a good value for the walls and the spill light from fixtures even if they are direct will achieve this criteria
- On the projector there should be less than 5 fc for visibility reasons

ASHRAE 90.1 Requirements

- For Classroom/Lecture → 1.4 W/ft^2
- A classroom also requires an automatic light shutoff 30 minutes after people leave the space

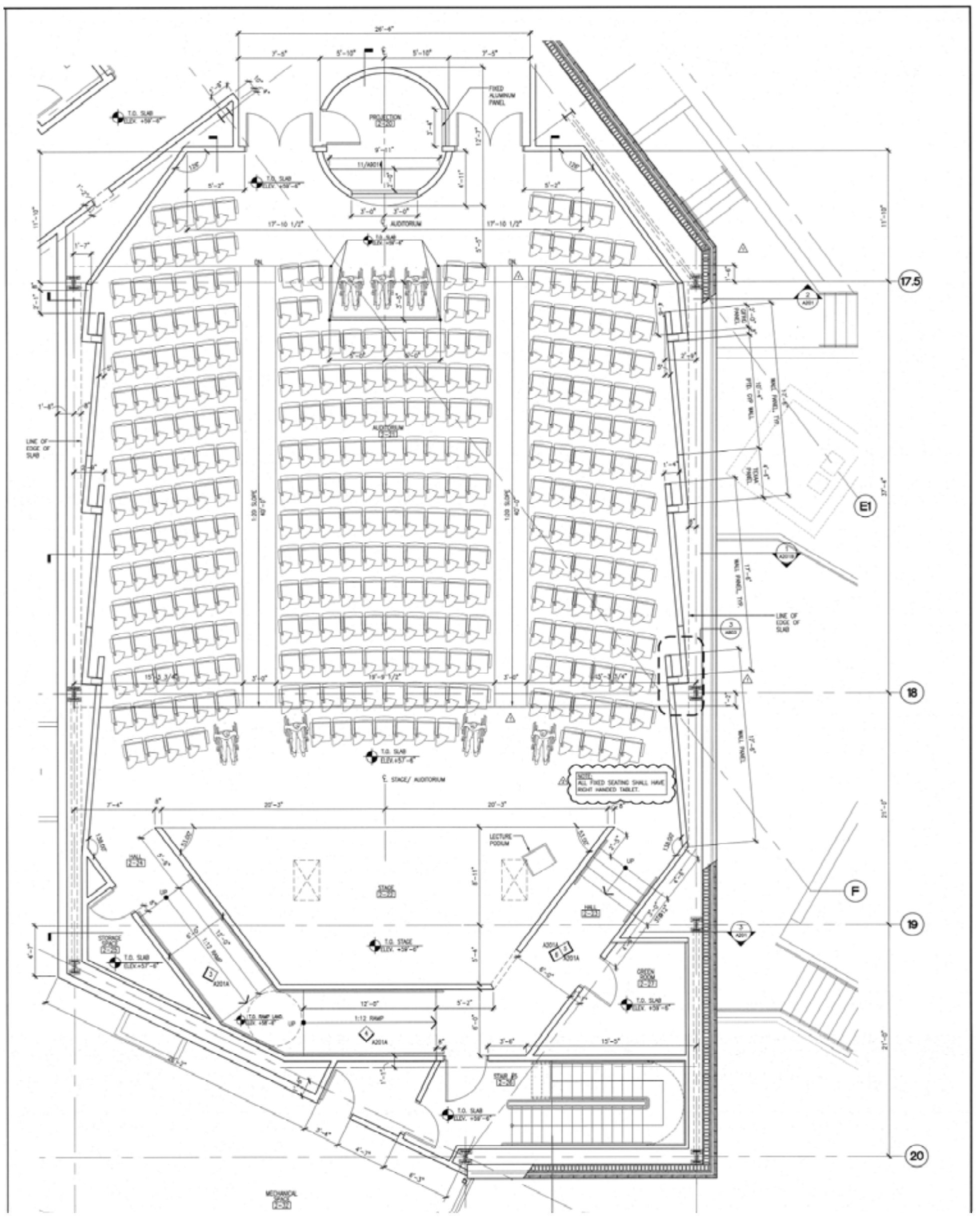
- An occupancy sensor of some sort will be required

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

PLANS

<u>Auditorium Enlarged Plan</u> (N.T.S.)
“Drawing A-201”

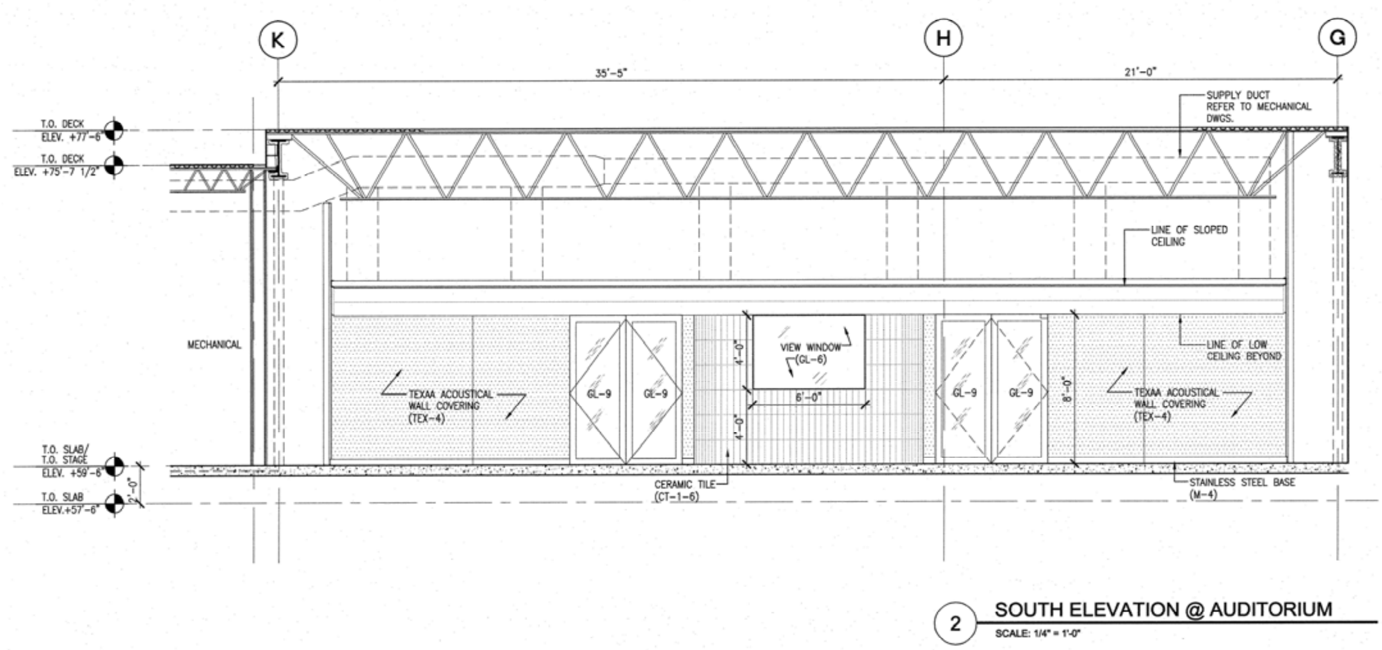


IV. LIGHTING DEPTH

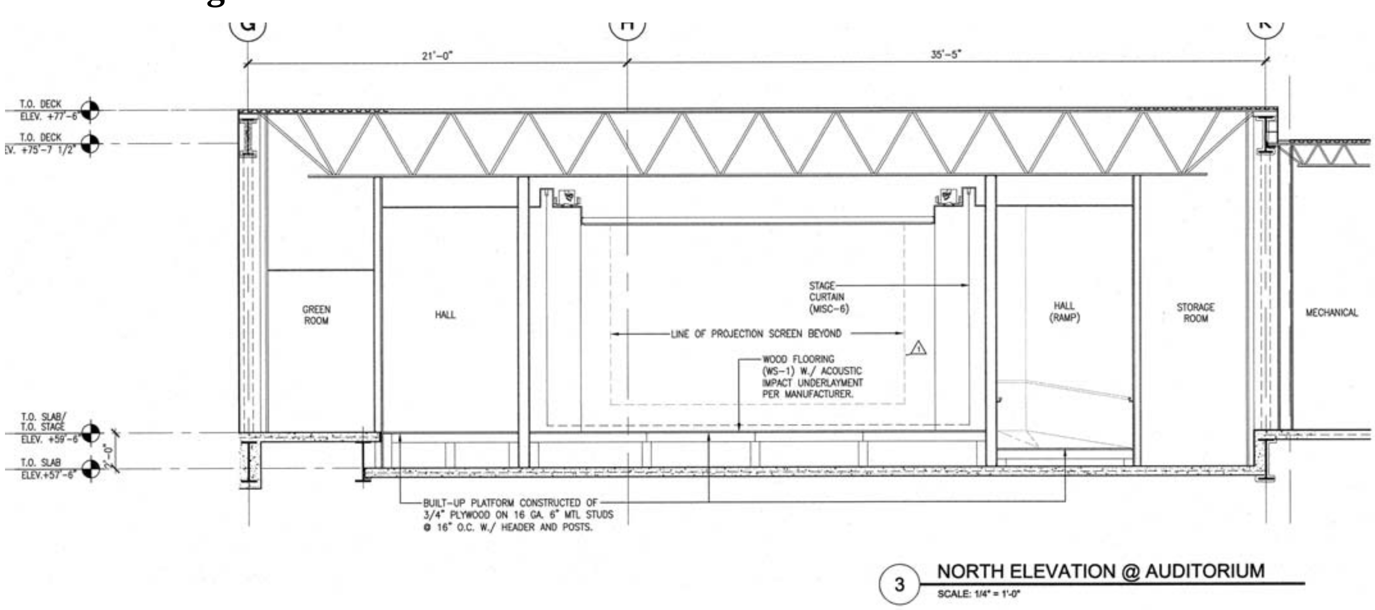
E.) AUDITORIUM REDESIGN

PLANS (CONT'D)

<u>Auditorium South Elevation</u> (N.T.S.)
"Drawing A-201"



<u>Classroom North Elevation</u> (N.T.S.)
"Drawing A-201"

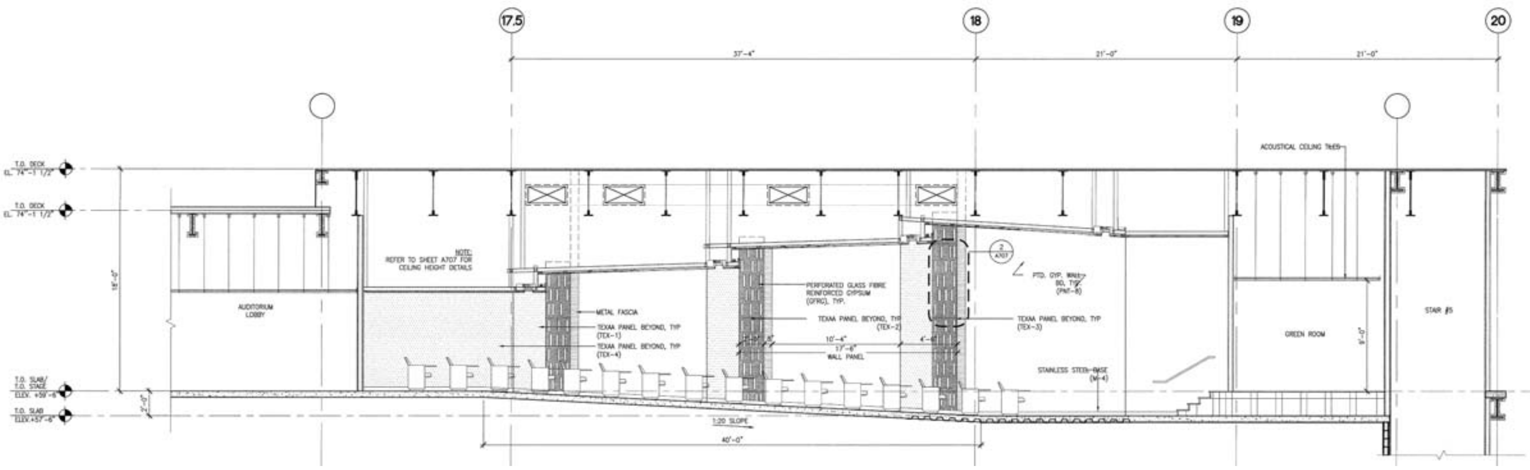


IV. LIGHTING DEPTH

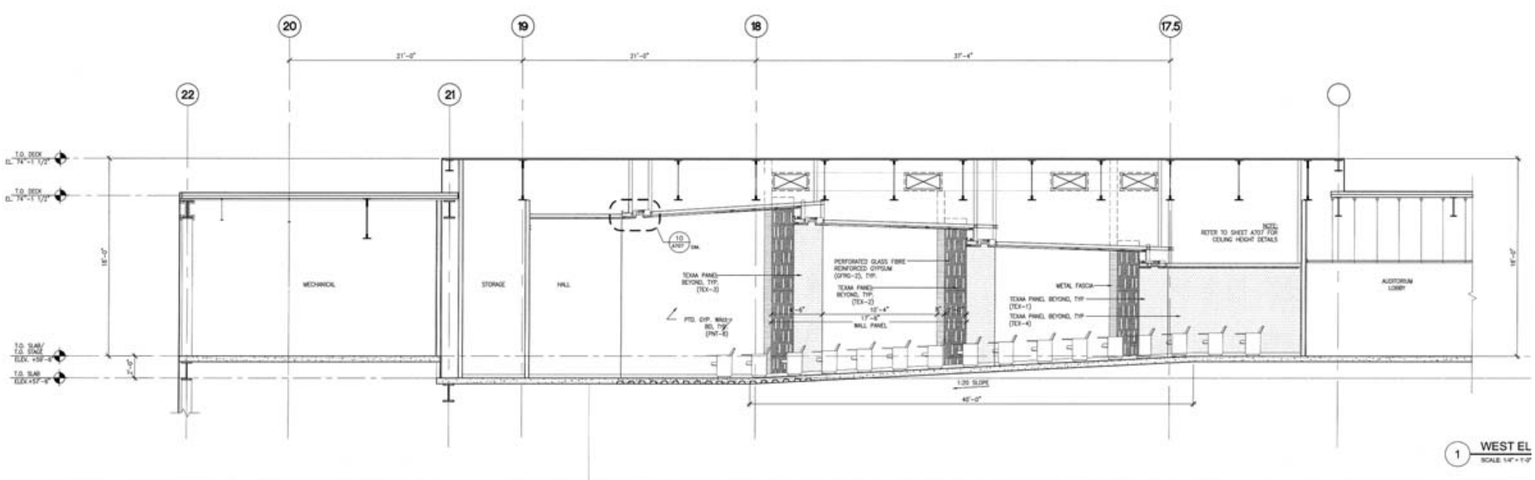
E.) AUDITORIUM REDESIGN

PLANS (CONT'D)

Auditorium East Elevation (N.T.S.)
"Drawing A-201A"



Auditorium West Elevation (N.T.S.)
"Drawing A-201A"



IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

DESIGN EXPLANATION

Design Concept

This design is intended to achieve a subjective impression of visual clarity by providing uniform illumination onto the task plane. The recessed lighting theme will be continued in this space. This space's architecture supports

Fixture Mounting

The luminaires chosen were both 1' x 4' linear fluorescent, however the wall washers are semi recessed while the fixture for the general illumination is recessed. The wall washers will be cut into the tile and mounted in a semi recessed fashion. The fixtures for general illumination are mounted recessed into a 1' gap between 2'x4' ceiling tiles.

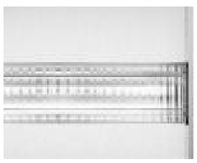
Luminaire Schedule

TYPE	IMAGE	MANUFAC-TURER	CATALOG #	DESCRIPTION	LAMP	VOLT-AGE	BALLAST	WATTS
J		ZUMTOBEL	VIVOM-39T45G85-S-WHM	METAL HALIDE ACCENT TRACK HEAD	(MasterColor # CDM-T 35W/830 T6 1CT) 35W 80 CRI 3000K CERAMIC METAL HALIDE	120V	N/A	39
K		ZUMTOBEL	VIVOM-39T45G85-F-WHM	4.5" HALOGEN WALL WASHER, RECESSED, WHITE TRIM	(MasterColor # CDM-T 35W/830 T6 1CT) 35W 80 CRI 3000K CERAMIC METAL HALIDE	120V	N/A	39
TRK		ZUMTOBEL	58621WH	1 CIRCUIT FLSU HPROFILE RECESSED TRACK	(MasterColor # CDM-T 35W/830 T6 1CT) 35W 80 CRI 3000K CERAMIC METAL HALIDE	120V	N/A	N/A

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

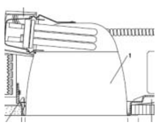
LUMINAIRE SHCEDULE

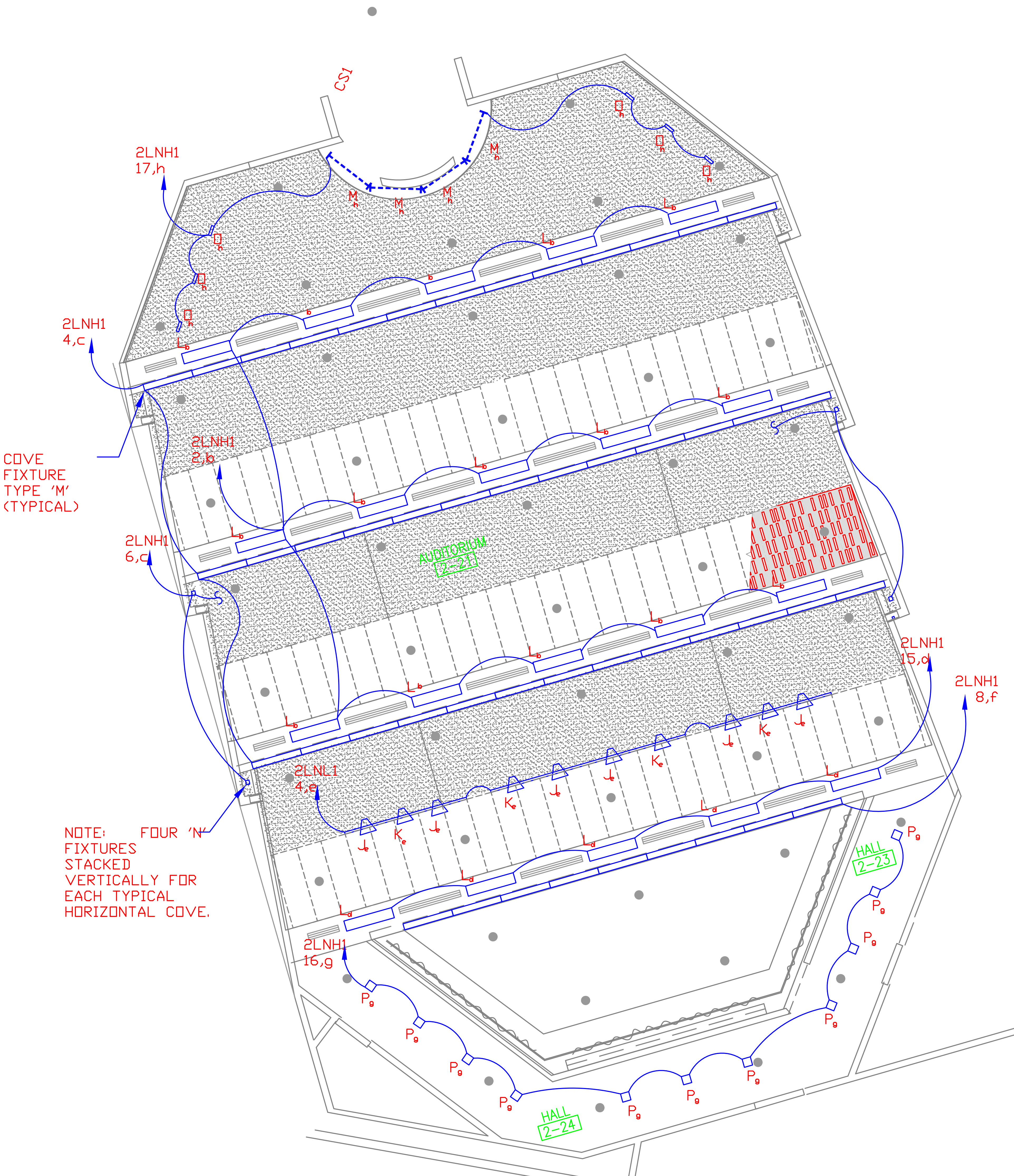
TYPE	IMAGE	MANUFAC-TURER	CATALOG #	DESCRIPTION	LAMP	VOLT-AGE	BALLAST	WATTS
L		ZUMTOBEL	ML4U-14-2328-MP-DE_2	1'X4' LINEAR FLUORESCENT W/ MICRO PYRAMIDAL OPTIC AND PRISMATIC LOWER LENS AND PRISMATIC ACRYLLIC SIDES	(2) 32W T5 4' LINEAR FLUORE-SCENT	277V	LUTRON ECO-10 CAT# ECO-T528 -277-2	69.25
M		LIGHT-CONTROL	COVE25 SERIES CC-AI-30-1-4-T8-CWM-ECO-1CWQ-277	1 LAMP T8 LINEAR COVE FIXTUREWHITE FINISH, ALUMINUM REFLECTOR, WHITE	(1) 32W T8 4' LINEAR FLUORE-SCENT SYLVANIA FO32/830/ XPS/ECO	277V	LUTRON ECO-10 CAT# ECO-T832 -277-1	38.8
N		LITE CONTROL	20-1-4-T8-CWM-ECO-277	4' LINEAR COVE FIXTURE MATTE WHITE FINISH, ALUMINUM REFLECTOR	(1) 32W T8 4' LINEAR FLUORE-SCENT SYLVANIA FO32/830/ XPS/ECO	277V	LUTRON ECO-10 ECO-T832-277-1-L	38.8
O		WINONA LIGHTING	WINONA WINDIRECT P1-SS-CFQ26-277V-SSRU-SGW-SO-STD	SMALL RECESSED SEMI RECESSED WALL WASHER ADJUSTABLE	(1) 26W COMPACT FLUORESC ENT	277V	LUTRON ECO-10 CAT# ECO-T528 --1	33.25

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

LUMINAIRE SHCEDULE (CONT'D)

TYPE	IMAGE	MANUFAC-TURER	CATALOG #	DESCRIPTION	LAMP	VOLT-AGE	BALLAST	WATTS
P		LIGHTOLIER	"CALCULITE" CFL OPEN DOWNLIGHT 8037CLW-S7126BU-J1LD3	7" SQUARE CFL (1 32W) TRIPLE TUBELAMP RECESSED DOWNLIGHT	(1)	277V	LUTRON COM-PACT SE 5% CAT# ECO-T528 - 120-1	36



AUDITORIUM LIGHTING RCP DIAGRAM

SUBMITTED FOR PROF. DANNERTH APRIL 7, 2009

NEW JERSEY CENTER FOR SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION

AE 482W JOHN MULHERN

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

CALCULATIONS

Light Loss Factors

Note : All calculations done in accordance with IESNA Handbook pp. 9-20 to 9-23. Assume all ballast factor are 1.0 unless otherwise noted. All initial and mean lumens were referenced from Osram Sylvania's Lamp and Ballast Catalog.

L

- Category V: Opaque unapertured top enclosure, translucent unapertured bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = e^(-At^{B}) = e^[-(0.078)(1 year)$^{0.53}$)
- LDD=0.902
- RCR ≈ 3, DD =10% → RSDD =0.98
- LLD = 4600 Mean lumens/5000 Initial Lumens = 0.94
- BF = 0.9
- PF = 0.98
- Total LLF = (0.902)(0.98)(0.94)(0.9)(0.98) = 0.733

M

- Category VI: No top enclosure, opaque unapertured bottom enclosure
- Very Clean environment → B=0.88, A=0.076
- Assume cleaning cycle is 12 months (1 year)
- LDD = e^(-At^{B}) = e^[-(0.076)(1 year)$^{0.88}$)
- LDD=0.927
- Category V, very clean → RSDD =0.93
- LLD = 3150 Mean lumens/3300 Initial Lumens = 0.95
- PF = 0.9
- Total LLF = (0.925)(0.94)(0.95)(1.0)(0.9) = 0.743

N

- Category VI: Opaque unapertured top enclosure, Opaque unapertured bottom enclosure
- Very Clean environment → B=0.88, A=0.076
- Assume cleaning cycle is 12 months (1 year)
- LDD = e^(-At^{B}) = e^[-(0.076)(1 year)$^{0.88}$)
- LDD=0.927
- Category V, very clean → RSDD =0.94
- LLD = 3150 Mean lumens/3300 Initial Lumens = 0.95
- PF = 0.9
- Total LLF = (0.925)(0.94)(0.95)(1.0)(0.9) = 0.743

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

CALCULATIONS (CONT'D)

<u>Light Loss Factors (cont'd)</u>

<u>O</u>

- Category V: Opaque unapertured top enclosure, translucent unapertured bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = e^(-At^{B}) = e^[-(0.078)(1 year)$^{0.53}$)
- LDD=0.902
- V → RSDD =0.94
- LLD = 1470 Mean lumens/1710 Initial Lumens = 0.86
- BF = 1.0
- PF = 0.9
- Total LLF = (0.902)(0.94)(0.86)(1.0)(0.9) = 0.79

<u>P</u>

- Category V: Opaque unapertured top enclosure, no bottom enclosure
- Very Clean environment → B=0.53, A=0.078
- Assume cleaning cycle is 12 months (1 year)
- LDD = e^(-At^{B}) = e^[-(0.078)(1 year)$^{0.53}$)
- LDD=0.925
- Category V, very clean → RSDD =0.94
- LLD = 3150 Mean lumens/3300 Initial Lumens = 0.95
- PF = 0.9
- Total LLF = (0.925)(0.94)(0.95)(1.0)(0.9) = 0.743

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

CALCULATIONS (CONT'D)

Power Density

Note : All calculations done in accordance with IESNA Handbook pp. 9-20 to 9-23. Assume all ballast factor are 1.0 unless otherwise noted. All initial and mean lumens were referenced from Osram Sylvania's Lamp and Ballast Catalog.

Room Area = 1284 SF

1.4 W/SF requirement ASHRAE Std. 90.1

K

- 5 Luminaires
- 41.5W/fixture
- 207.5 W

J

- 5 luminaires
- 41.5 W/fixture
- 207.5 W

L

- 20 luminaires
- 69.25 W/fixture
- 1385 W

M

- 5 luminaires
- 41.5 W/fixture
- 207.5

N

- 48 luminaires
- 38.8 W/fixture
- 1862.4 W

O

- 6 luminaires
- 33.25 W/fixture
- 199.5 W

IV. LIGHTING DEPTH

E.) AUDITORIUM REDESIGN

CALCULATIONS (CONT'D)

Power Density (cont'd)

P

- 11 luminaires
- 36 W/fixture
- 396 W

4672.7 TOTALWATTS /4097 SF

1.14 W/SF

IV. LIGHTING DEPTH

D) AUDITORIUM

LECTURE MODE RESULTS

The new ceiling height proved difficult to achieve the 30 fc criteria for reading and writing. The linear fluorescents were placed in between the linear diffusers, which gives the ceiling some order despite being staggered at random angles. The light could stay there because this situation is when the lamps are nearing replacement. For the majority of the time there will be college students here, so they have a lot better eyesight than older people

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
Task_2	Illuminance	Fc	0.00	0.0	0.0	N.A.	N.A.
Task Plane	Illuminance	Fc	27.74	36.2	19.4	1.43	1.87
Carpet_1_Back Vestibule	Illuminance	Fc	15.13	24.0	5.6	2.70	4.29
Task Plane_Left	Illuminance	Fc	24.12	33.4	14.1	1.71	2.37
Task Plane_Right	Illuminance	Fc	25.42	33.3	16.5	1.54	2.02
Floor in front of stage_No chair	Illuminance	Fc	30.82	84.2	20.2	1.53	4.17
Carpet1_Carpet1	Illuminance	Fc	31.62	35.1	27.9	1.13	1.26

FIG. A-1
CALCULATION SUMMARY LECTURE MODE

IV. LIGHTING DEPTH

D) AUDITORIUM

LECTURE MODE RESULT(CONT'D)

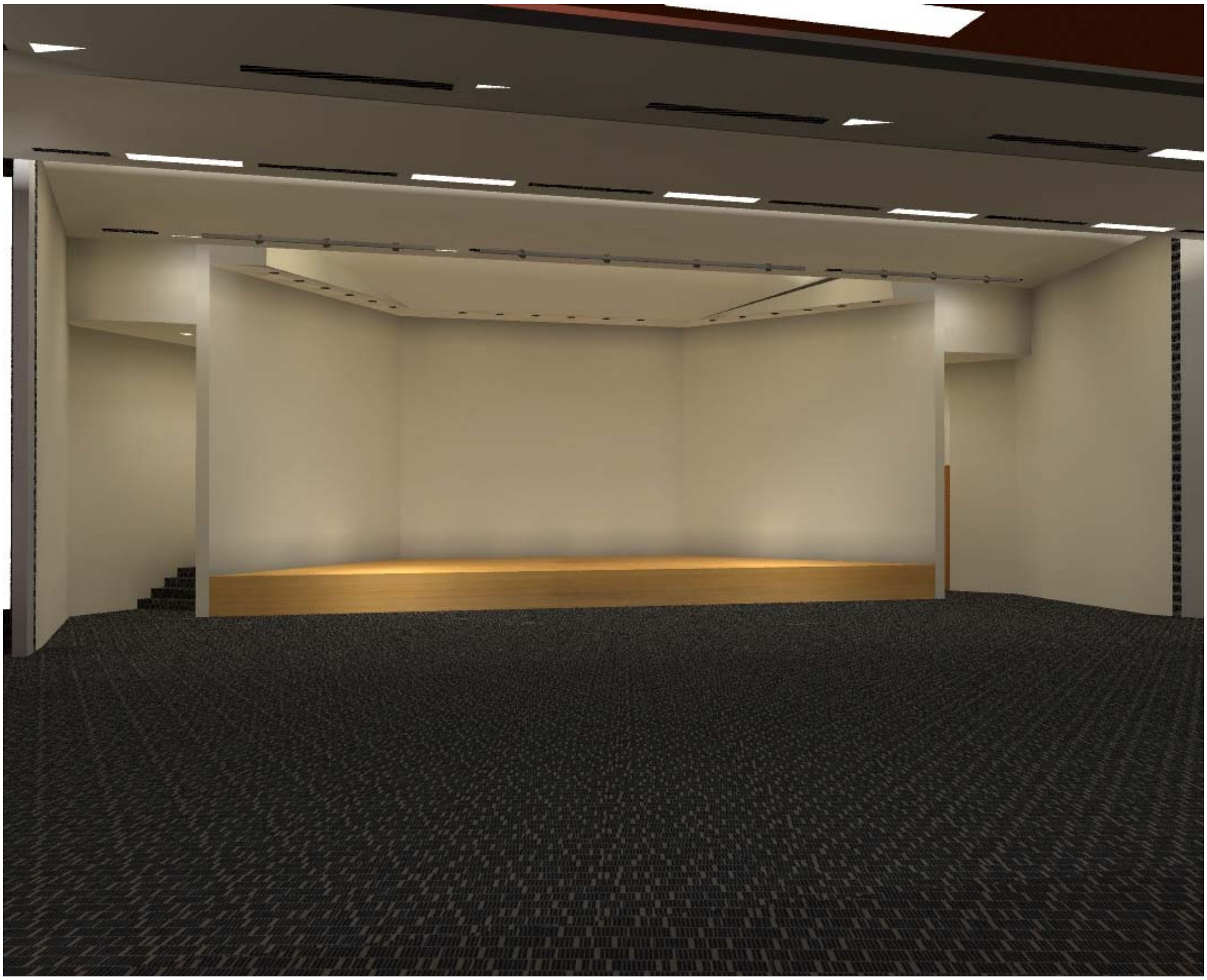


FIG. A-2A
PERSPECTIVE RENDERING OF WHITEBOARD

IV. LIGHTING DEPTH

D) AUDITORIUM

LECTURE MODE RESULT(CONT'D)

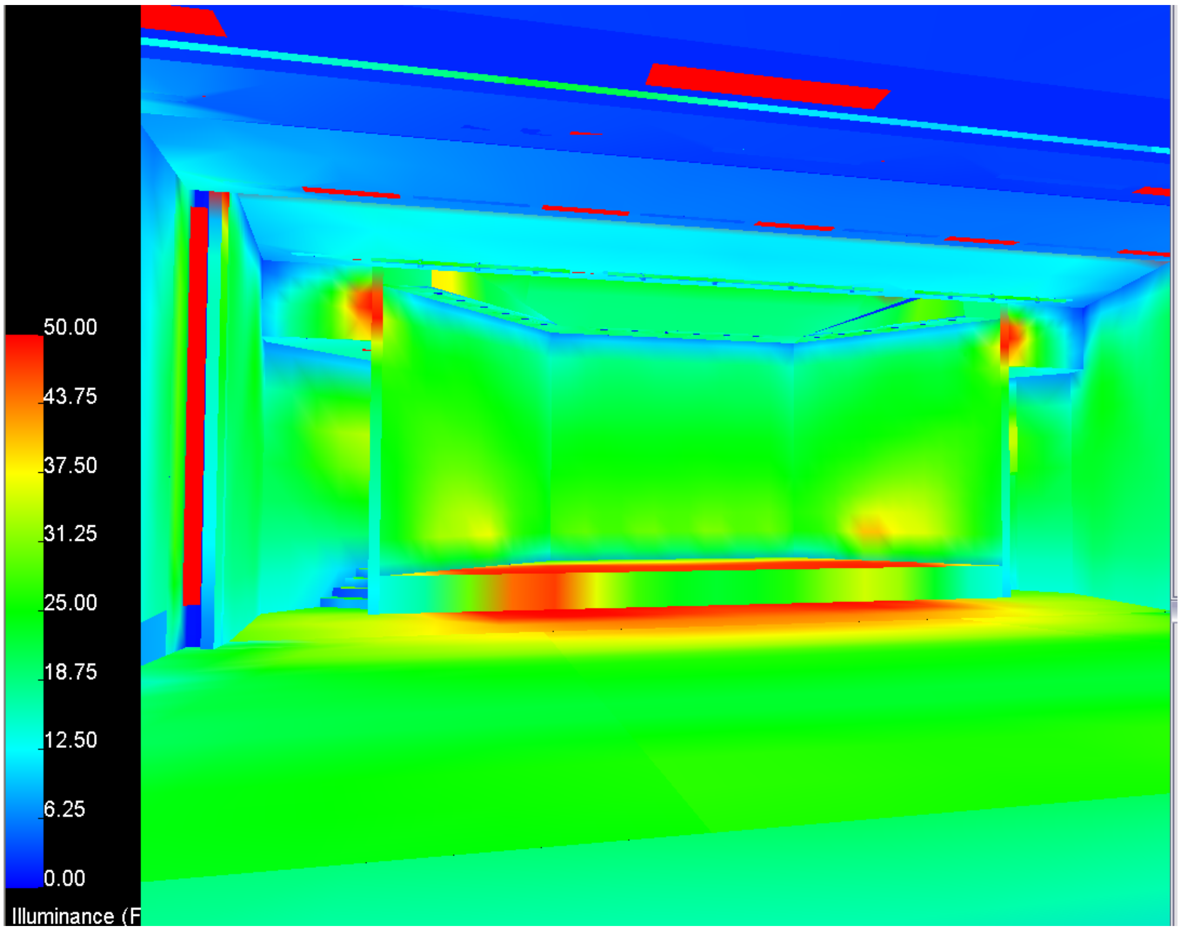


FIG. A-2B
PERSPECTIVE ILLUMINANCE PSEUDOCOLOR OF WHITEBOARD

IV. LIGHTING DEPTH

A) CLASSROOM REDESIGN

INTRODUCTION

Description of Space

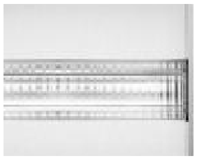
This is a simple college classroom. It seats 42 students with a desk for the teacher in the front of the classroom. The room is rectangular with approximate dimensions of 26' X 41'(Length X Width). There are no heavy electrical loads in this space. There is a projector mounted on the ceiling.

Design Concept

The new lighting design theme for this space is inspired by a circuit board. A circuit board is almost flat with linear strips of light. This concept was translated into this space by providing only recessed and semi recessed lighting in order to have a clean appearance for the ceiling. This design is intended to achieve a subjective impression of visual clarity by providing uniform illumination onto the task plane. The whiteboard will have a higher luminance than the lateral walls so that students will concentrate on it during class.

Fixture Mounting

The luminaires chosen were both 1' x 4' linear fluorescent, however the wall washers are semi recessed while the fixture for the general illumination is recessed. The wall washers will be cut into the tile and mounted in a semi recessed fashion. The fixtures for general illumination are mounted recessed into a 1' gap between 2'x4' ceiling tiles.

TYPE	IMAGE	MANUFAC-TURER	CATALOG #	DESCRIPTION	LAMP	VOLT-AGE	BALLAST	WATTS
A		ZUMTOBEL	ML4U-14-1285-MP	1'X4' LINEAR FLUORESCENT W/ MICRO PYRAMIDAL OPTIC AND PRISMATIC LOWER LENS AND PRISMATIC ACRYLLIC SIDES	(1) 28W T5 4' LINEAR FLUORE-SCENT	277V	LUTRON ECO-10 CAT# ECO-T528 - 277-2	38.8
B		ELLIPTIPAR	F210-T128-L-02-V-00-0	1'X4' LINEAR FLUORESCENT WALLWASHER W/ SPECULAR REFLECTOR	(1) 28W T5 4' LINEAR FLUORE-SCENT	277V	LUTRON ECO-10 CAT# ECO-T528 - 277-2	38.8

V. ELECTRICAL DEPTH

A) CLASSROOM REDESIGN

CRITERIA/CONTROLS

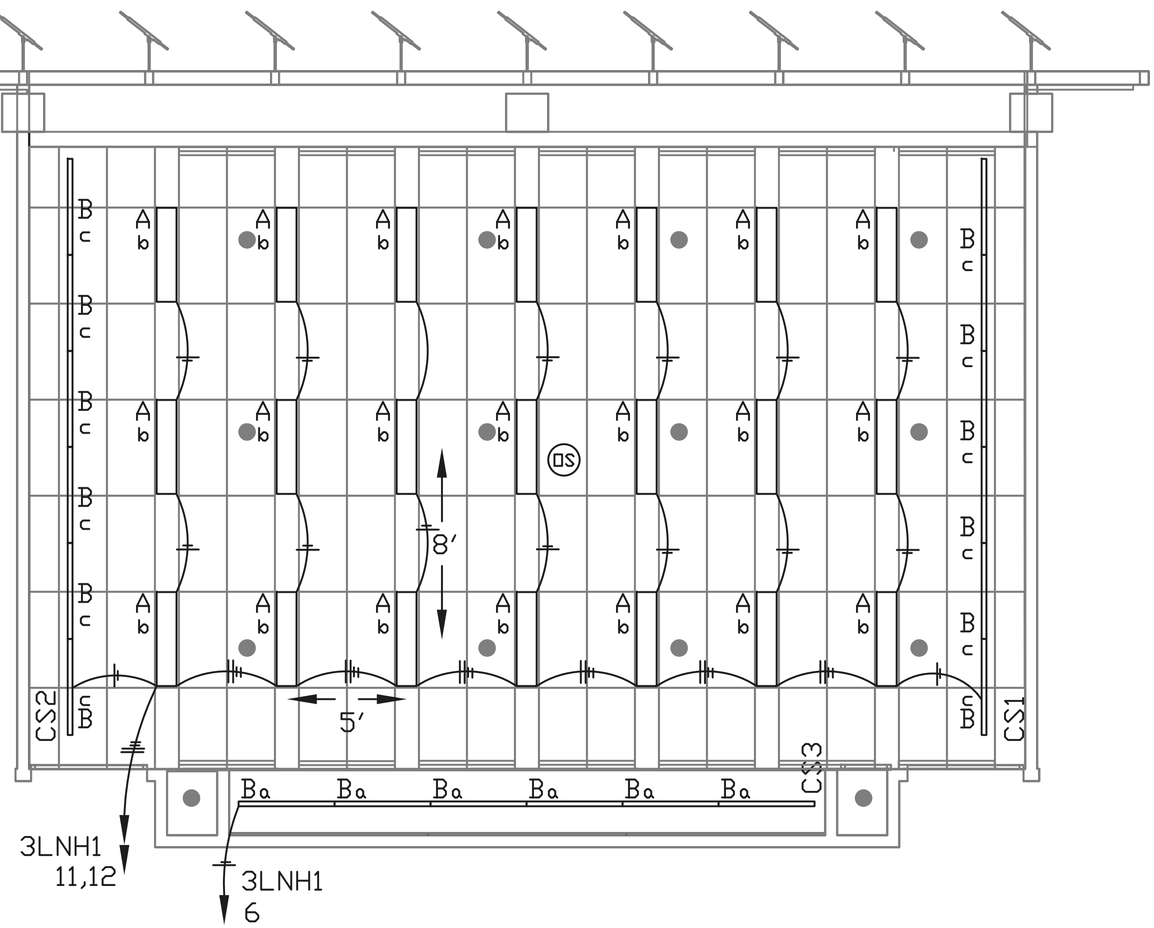
Luminaire Schedule

The classroom space will need controls for scenes such as for a projector. This building is intended to be LEED Gold Rated, so lighting and controls should promote the conservation of energy. Only linear fluorescent luminaires were specified. Lutron controls are specified for this project.. There is plenty of available space on '3LNH1' because it is a 480Y/277V panel board. There is no necessity to load up circuits due to lack of space.

This space will be controlled specifically by a GRAFIK Eye system made by Lutron. The luminaires will be grouped into three zones. Zone "a" is comprised of the wall wash fixtures for the whiteboard. Zone "b" is for the luminaires which provide the task illumination. The final zone "c" is for the side wall washers. Lutron requires a circuit for each zone and neutrals cannot be shared. There will be control stations at both doors for a general ON/OFF function along with a preset for the 'Classroom Scene'. Control Station "CS3" will contain the 2 scene preset buttons for the general classroom and presentation modes as well as a general OFF switch. The fourth preset will be a spare in case the teacher wants to make an adjustment to the light output. The dimming output levels of each zone are specified in the 'Lighting Depth' section of this report.

The lighting circuits are fed through a branch breaker style dimming panel ('DP3') made by Lutron. This means that there still are 20A branch circuits for each zone in power panel '3LNH1' as well as in 'DP3'. The control system 'GRX-IO' has inputs for the occupancy sensor. This occupancy sensor only turns the lights off. A teacher or a student will have to press a preset button to turn the luminaires on. Please refer to the appendix for specifications and wiring diagrams for the GRAFIK Eye System.

NOTE: ALL HOMERUNS TO POWER PANEL '3LNH1' THROUGH DIMMING PANEL 'DP3' (BRANCH BREAKER TYPE)



1 CLASSROOM 3-07 - LIGHTING RCP

SCALE: 1/8"=1'0".

AE 482W
JOHN MULHERN

NEW JERSEY CENTER FOR SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION

SUBMITTED FOR PROF. DANNERTH APRIL 7, 2009

CLASSRM. LIGHTING RCP DIAGRAM

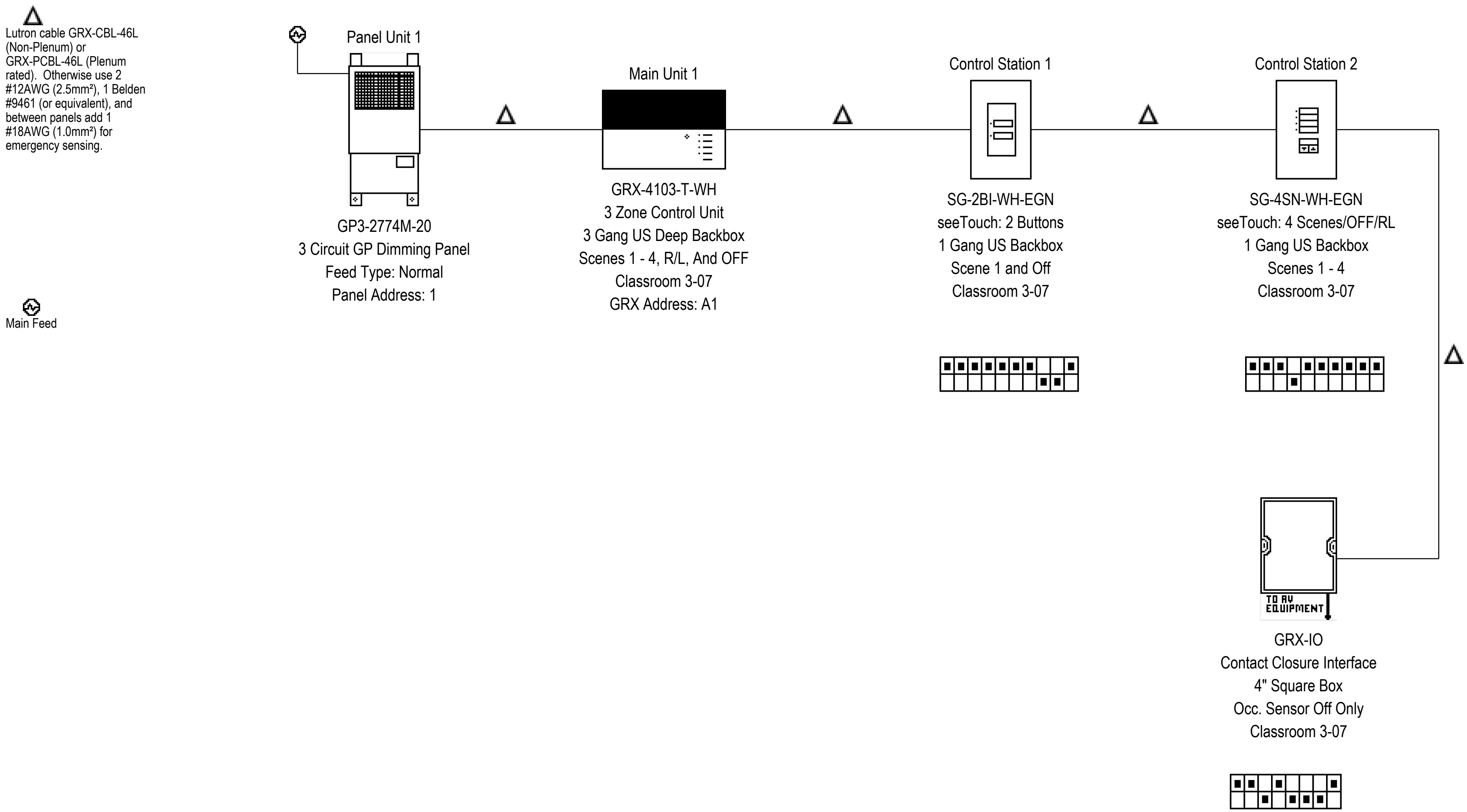
V. ELECTRICAL DEPTH

A) CLASSROOM REDESIGN

NEW DIMMER SCHEDULE

DP3' DIMMING PANEL SCHEDULE

DP3 (Branch Breaker Type)								
Zone	Description	3LNH1 CKT. #	Fixture Type	Voltage	Load Type	Load(W) Per Fixture	Quantity	Total Load(W)
a	Whiteboard	6	B	277V	Fluor - ECO-10	39	6	234
b	General Illumination	11	A	277V	Fluor - ECO-10	39	21	819
c	Side Wall Washes	12	B	277V	Fluor - ECO-10	39	12	468



LUTRON	**Project Name:** Senior Thesis 2009	**System:** New System 1
	Location: Union, NJ	**Design By:** John P Mulhern
www.lutron.com	**Project #:** Kean University	**Project Filename:** Senior Thesis 2009 Lutron Controls Design.gdf
Toll Free: 800 523 9466	GRAFIK Eye Designer 7.1.124	**Date:** 7-Apr-2009 **Page:** 1 of 1

V. ELECTRICAL DEPTH

A) CLASSROOM REDESIGN

EXISTING PANELBOARD SCHEDULE

LOCATION:	ELEC. CLOSET 3-10	**REMARKS:**	**PANEL DESIGNATION:** 3LNH1 (LIGHTING)
SERVICE:	277/480 **VOLTS,** 3 **PHASE,** 4 **WIRE**		
MAINS:	100 **AMPS**	**MAIN OVERCURRENT PROTECTION:**	
MOUNTING TYPE:	SURFACE	**M.C.B.:**	
GROUNDING:	GROUND BUS: **YES** ISOLATED GRD BUS: -	**M.L.O.:** **YES** **POLES:** 42	

	CONN. KVA								CONN. KVA			
SERVICE TO:	**A**	**B**	**C**	**SIZE**	**NO.**		**NO.**	**SIZE**	**A**	**B**	**C**	**SERVICE TO:**
3RD FLR. - CLASSROOM 3-06 LTG.	2.52			20	1	-	2	20	-			SPARE
3RD FLR. - ELEC. /SUP. SP. LTG.		2.96		20	3		4	20		-		SPARE
3RD FLR. - CORRIDOR LTG.			3.24	20	5		6	20			-	SPARE
3RD FLR. - CORRIDOR LTG.	2.68			20	7	-	8	20	-			SPARE
3RD FLR. - ELEV. CORE LTG.		1.56		20	9		10	20		-		SPARE
3RD FLR. - CLASSROOM 3-07LTG.			2.60	20	11		12	20			-	SPARE
3RD FLR. - CLASSROOM LTG.	2.76			20	13	-	14	20	-			SPARE
3RD FLR. - CLASSROOM LTG.		2.40		20	15		16	20		-		SPARE
3RD FLR. - CLASSROOM LTG.			2.12	20	17		18	20			-	SPARE
3RD FLR. - CLASSROOM LTG.	3.72			20	19	-	20	20	-			SPARE
SPARE		-		20	21		22	20		-		SPARE
SPARE			-	20	23		24	20			-	SPARE
SPARE	-			20	25	-	26	20	-			SPARE
SPARE		-		20	27		28	20		-		SPARE
SPARE			-	20	29		30	20			-	SPARE
SPARE	-			20	31	-	32	20	-			SPARE
SPARE		-		20	33		34	20		-		SPARE
SPARE			-	20	35		36	20			-	SPARE
SPARE	-			20	37	-	38	20	-			SPARE
SPARE		-		20	39		40	20		-		SPARE
SPARE			-	20	41		42	20			-	SPARE
SUBTOTALS	11.7	6.9	8.0						0.0	0.0	0.0	

TOTAL LOADS:	11.7	**KVA PHASE A**	24.3 **A PHASE A**	**CONNECTED LOAD (PWR):**		0.0 KVA
	6.9	**KVA PHASE B**	14.4 **A PHASE B**	**DEMAND FACTOR (PWR):**		80%
	8.0	**KVA PHASE C**	16.6 **A PHASE C**	**CONNECTED LOAD (LTG):**		26.6 KVA
				DEMAND FACTOR (LTG):		100%
				DEMAND LOAD:		26.6 KVA
TOTAL CONNECTED LOAD:	26.6	**KVA**		**DEM. LOAD x** 1.25	**SPARE:**	33.2 KVA
				AMP: **(at** 480	**V)**	40 A

V. ELECTRICAL DEPTH

A) CLASSROOM REDESIGN

NEW PANELBOARD SIZING WORKSHEET

‘3LNH1’ New Panel board Sizing Worksheet

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->				3LNH1	Panel Location:		Elec. Closet 3-10				
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	3-06	2520	w	0.95	2520	2653		
2	A	Lighting	3	Corr. 3-09	2960	w	0.95	2960	3116		
3	B	Lighting	3	Corr. 3-27	3240	w	0.95	3240	3411		
4	B	Lighting	3	Corr. 3-05	2680	w	0.95	2680	2821		
5	C	Lighting	3	Cor 3-05,06	1560	w	0.95	1560	1642		
6	C	Zone 'a'	3	3-07	1513	w	0.95	1513	1593		
7	A	Lighting	3	3-24	2760	w	0.95	2760	2905		
8	A	Lighting	3	24-Mar	2400	w	0.95	2400	2526		
9	B	Lighting	3	3-22,23	2120	w	0.95	2120	2232		
10	B	Lighting	3	3-17,18	3720	w	0.95	3720	3916		
11	C	Zone 'b'	3	3-07	819	w	0.95	819	862		
12	C	Zone 'c'	3	3-07	234	w	0.95	234	246		
13	A	spare	3		3545	w	0.95	3545	3732		
14	A	spare	3		3545	w	0.95	3545	3732		
15	B	spare	3		3545	w	0.95	3545	3732		
16	B	spare	3		3545	w	0.95	3545	3732		
17	C	spare	3		3545	w	0.95	3545	3732		
18	C	spare	3		3545	w	0.95	3545	3732		
19	A	space				w	1.00	0	0		
20	A	space				w	1.00	0	0		
21	B	space				w	1.00	0	0		
22	B	space				w	1.00	0	0		
23	C	space				w	1.00	0	0		
24	C	space				w	1.00	0	0		
25	A	space				w	0.95	0	0		
26	A	space				w	0.95	0	0		
27	B	space				w	0.95	0	0		
28	B	space				w	0.90	0	0		
29	C	space				w	0.90	0	0		
30	C	space				w	0.90	0	0		
31	A	space				w	1.00	0	0		
32	A	space				w	1.00	0	0		
33	B	space				w	1.00	0	0		
34	B	space				w	1.00	0	0		
35	C	space				w	1.00	0	0		
36	C	space				w	1.00	0	0		
37	A	space				w	1.00	0	0		
38	A	space				w	1.00	0	0		
39	B	space				w	1.00	0	0		
40	B	space				w	1.00	0	0		
41	C	space				w	1.00	0	0		
42	C	space				w	1.00	0	0		
PANEL TOTAL								47.8	50.3	Amps=	60.5
PHASE LOADING							kW	kVA	% Total	Amps	% +/-
PHASE TOTAL			A				17.7	18.7	37%	67.4	11.29%
PHASE TOTAL			B				18.9	19.8	39%	71.6	18.32%
PHASE TOTAL			C				11.2	11.8	23%	42.6	-29.60%

V. ELECTRICAL DEPTH

A) CLASSROOM REDESIGN

NEW PANELBOARD LOAD CATEGORIES

‘3LNH1’ New Panel board Load Categories

LOAD CATAGORIES			Connected			Demand				
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0	0.70	0.0	0.0			
2	computers		0.0	0.0	0.90	0.0	0.0			
3	fluorescent lighting		47.8	50.3	1.00	47.8	50.3	0.95		
4	HID lighting		0.0	0.0	1.00	0.0	0.0			
5	incandescent lighting		0.0	0.0	1.00	0.0	0.0			
6	HVAC fans		0.0	0.0	0.80	0.0	0.0			
7	heating		0.0	0.0	1.25	0.0	0.0			
8	kitchen equipment		0.0	0.0	0.80	0.0	0.0			
Total Demand Loads						47.8	50.3			
Spare Capacity			45%			21.5	22.6			
Total Design Loads						69.3	73.0	0.95	Amps=	87.8

V. ELECTRICAL DEPTH

A) CLASSROOM REDESIGN

NEW PANELBOARD SCHEDULE

‘3LNH1’ New Panel board Schedule

PANELBOARD SCHEDULE													
VOLTAGE: 480Y/277V,3PH,4W SIZE/TYPE BUS: 100A SIZE/TYPE MAIN: 90A/3P C/B				PANEL TAG: 3LNH1 PANEL LOCATION: Elec. Closet 3-10 PANEL MOUNTING: SURFACE						MIN. C/B AIC: 35K OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 3LNH1			
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION	
Lighting	3-06	2520	20A/1P	1	*			2	20A/1P	2960	Corr. 3-09	Lighting	
Lighting	Corr. 3-27	3240	20A/1P	3		*		4	20A/1P	2680	Corr. 3-05	Lighting	
Lighting	Cor 3-05,06	1560	20A/1P	5			*	6	20A/1P	1513	3-07	Zone 'a'	
Lighting	3-24	2760	20A/1P	7	*			8	20A/1P	2400	39896	Lighting	
Lighting	3-22,23	2120	20A/1P	9		*		10	20A/1P	3720	3-17,18	Lighting	
Zone 'b'	3-07	819	20A/1P	11			*	12	20A/1P	234	3-07	Zone 'c'	
spare	0	3545	20A/1P	13	*			14	20A/1P	3545	0	spare	
spare	0	3545	20A/1P	15		*		16	20A/1P	3545	0	spare	
spare	0	3545	20A/1P	17			*	18	20A/1P	3545	0	spare	
space	0	0	^	19	*			20	^	0	0	space	
space	0	0	^	21		*		22	^	0	0	space	
space	0	0	^	23			*	24	^	0	0	space	
space	0	0	^	25	*			26	^	0	0	space	
space	0	0	^	27		*		28	^	0	0	space	
space	0	0	^	29			*	30	^	0	0	space	
space		0	^	31	*			32	^	0		space	
space		0	^	33		*		34	^	0		space	
space		0	^	35			*	36	^	0		space	
space		0	^	37	*			38	^	0		space	
space		0	^	39		*		40	^	0		space	
space		0	^	41			*	42	^	0		space	
CONNECTED LOAD (KW) - A		17.73								TOTAL DESIGN LOAD (KW)		69.30	
CONNECTED LOAD (KW) - B		18.85								POWER FACTOR		0.95	
CONNECTED LOAD (KW) - C		11.22								TOTAL DESIGN LOAD (AMPS)		88	

V. ELECTRICAL DEPTH

A) CLASSROOM REDESIGN

FEEDER SIZING TABLE

'3LNH1' New Feeder Sizing Table

Breaker and Feeder Size

FOR DESIGN AMPACITY OF 87.8 A

SELECT 90A/3P CIRCUIT BREAKER

(4) #3AWG & #8AWG GROND WIRE

Assumptions

The panel was sized for 20 % spare capacity in case a room was changed in the future with more intensive lighting than there is designed for now. Because this panel only provides power for lighting loads, harmonics were an issue. An extra 25% was added to size the wire and the main circuit breaker and conductor in order to accommodate for the harmonics caused by fluorescent ballasts. There were not many spares provided because many luminaires can be placed on one circuit of a 480/277V panel board.

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

INTRODUCTION

Description

This lecture hall has approximately 280 students with fold out desks. The ceiling has multiple slopes with heights ranging from 8', 10', 11.5', 12', and 12.5'. It has a jagged shape when viewed in section. There are three sections of seats with two aisles. There is a stage area where most likely a teacher will have a desk onto which he or she will place his belongings. The walls are made of acoustic material for sound absorption to prevent echoes. The walls have a jagged shape in plan for acoustic reflections. The floors are made of carpet with a rubber base underneath. There is also a projector room which will house the projector and controls for presentations.

Tasks

There are multiple tasks in this auditorium building. First and foremost there are many desks. There will be approximately 280 students reading and writing in this classroom during lectures. This is an important task to consider for lighting design criteria. The projection screen is another important task for the students. There must not be a lot of glare. The professor also has to read his own lecture notes on his podium/desk and talk to the class on a microphone system.

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

INTRODUCTION(CONT'D)

Design Concept

The new lighting design theme for this space is inspired by a circuit board. A circuit board is almost flat with linear strips of light. This concept was translated into this space by providing only recessed and semi recessed lighting in order to have a clean appearance for the ceiling.

This design is intended to achieve a public subjective impression by providing uniform illumination onto the task plane. There will be higher ambient luminance levels in the general lobby area. There will also be peripheral emphasis on only the ceramic tile wall because there is only curtain wall everywhere else. More peripheral lighting would have been desirable, but lighting the curtain wall would have been a waste because of all the glass. Most of the surfaces chosen in the original architectural design are light, so this helps reinforce the public impression. This design is intended for the normal lobby function of the space.

For the gala scene, a private subjective impression is desired. The linear fluorescent fixtures were dimmed to 20% output for low ambient illuminance. There is some peripheral emphasis like the last scene with the ceramic wall being washed. This creates luminance away from the occupant which gives people light to observe away from their general area. Also the café area will be brighter because it will most likely be turned into a bar at these events.

As desired in the schematic phase the linear strips of light guide the occupants to their destination. The top row of luminaires guide occupants to the remainder of the first floor. The second row is for guiding to the grand staircase to the Exhibition Space. The third row shows the path to the elevator lobby. The final row closest to the south façade guides occupants

Fixture Mounting

The luminaire chosen for general illumination was a recessed linear fluorescent with staggered lamps to eliminate socket shadows. The wall washers for the ceramic tile wall are semi recessed ceramic metal halide fixtures. For the elevator lobby portion there are recessed fluorescent down lights that are wall washers. This was chosen to attract people to the elevators for circulation.

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

CRITERIA/CONTROLS

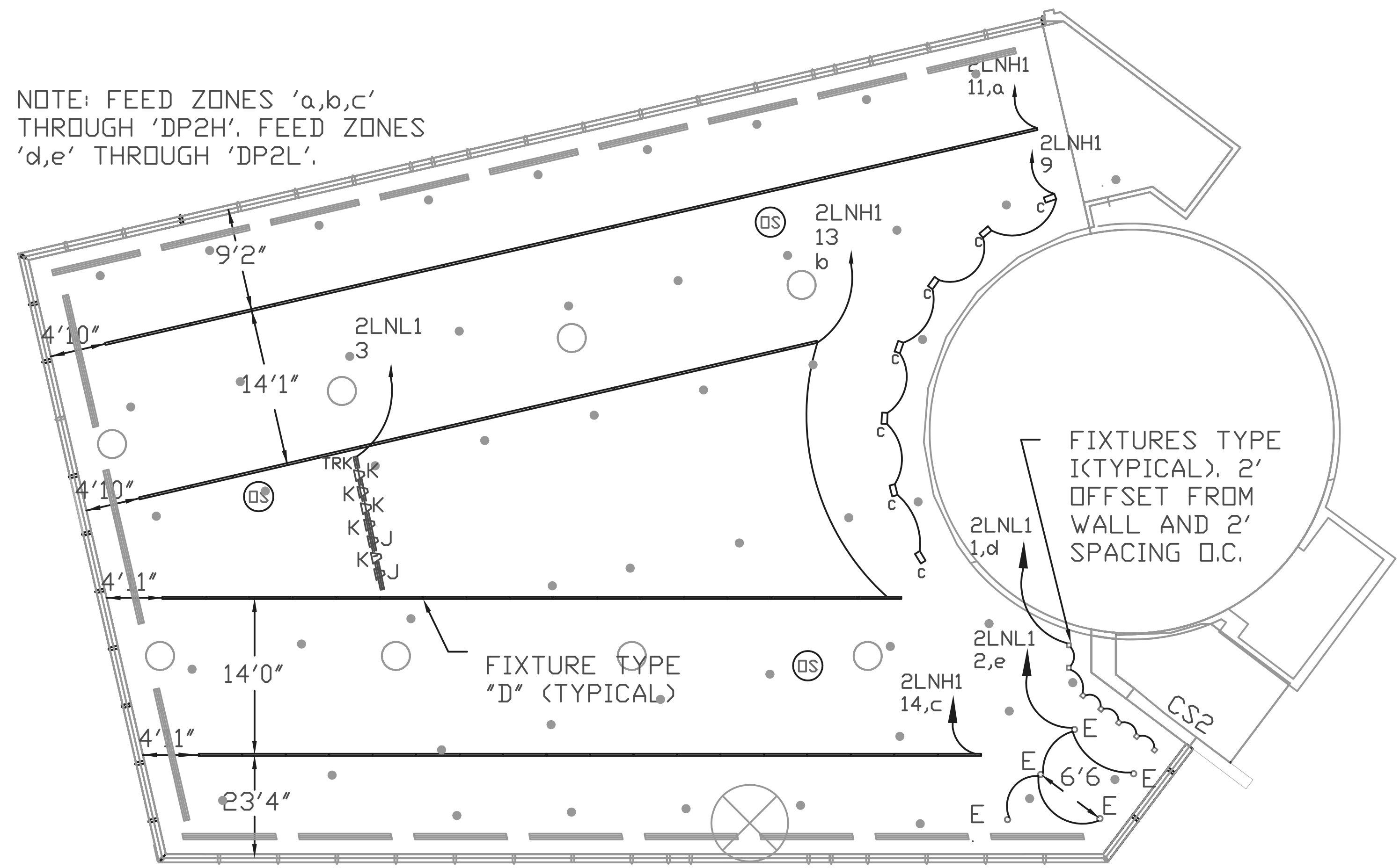
Controls will be necessary for this space also because it requires two lighting scenes. The first scene will be for a normal building lobby. The other scene is for gala events. These occur very infrequently, however, when the time comes for an event, controls make life easier for the staff of this building. The theme of recessed fixtures is continued into this space. Also energy efficient fluorescent lighting is utilized for most of the space.

This space will be controlled by a GRAFIK Eye system made by Lutron. The luminaires will be grouped into five zones. Zone "a" is comprised of the north row of fixture type 'C'. Zone 'b' includes the 2 middle rows of these fixtures. Zone 'c' includes the southern row of these fixtures. These were split up for daylighting reasons in order to dim evenly.

The lighting circuits are fed through a branch breaker style dimming panel ('DP2H') made by Lutron. This means that there still are 20A branch circuits for each zone in power panel '2LNH1' as well as in 'DP2H'. The control system 'GRX-IO' has inputs for the occupancy sensor. This occupancy sensor only turns the lights off. A teacher or a student will have to press a preset button to turn the luminaires on. Please refer to the appendix for specifications and wiring diagrams for the GRAFIK Eye System.

In the redesign of the lobby space, some 120V halogen fixtures were specified. This caused a problem because all of the fluorescent lighting was operating at 277V. Another dimming panel, 'DP2L', was required for these halogen fixtures. The two dimming panels are connected by Lutron cable and utilize the same control unit. Zone 'd', the café wall washers, and Zone 'e', the halogen pendants, will be routed through this panel.

A time clock will be connected to turn the lights off during holiday season. The luminaires will most likely be on all the time because it is a college building, and students may have to work late. Lutron requires a circuit for each zone and neutrals cannot be shared. There will be control stations at the café storage room, and at the reception desk on the second floor. The control stations will have an OFF function along with a preset for the 'Lobby Scene' and the 'Gala Scene'. Control Station. The fourth preset will be a spare in case the staff wants to make an adjustment to the light output. The dimming output levels of each zone are specified in the 'Lighting Depth' section of this report.



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NEW JERSEY CENTER FOR SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION

SUBMITTED FOR
PROF. DANNERTH
APRIL 7, 2009

LOBBY LIGHTING RCP DIAGRAM

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

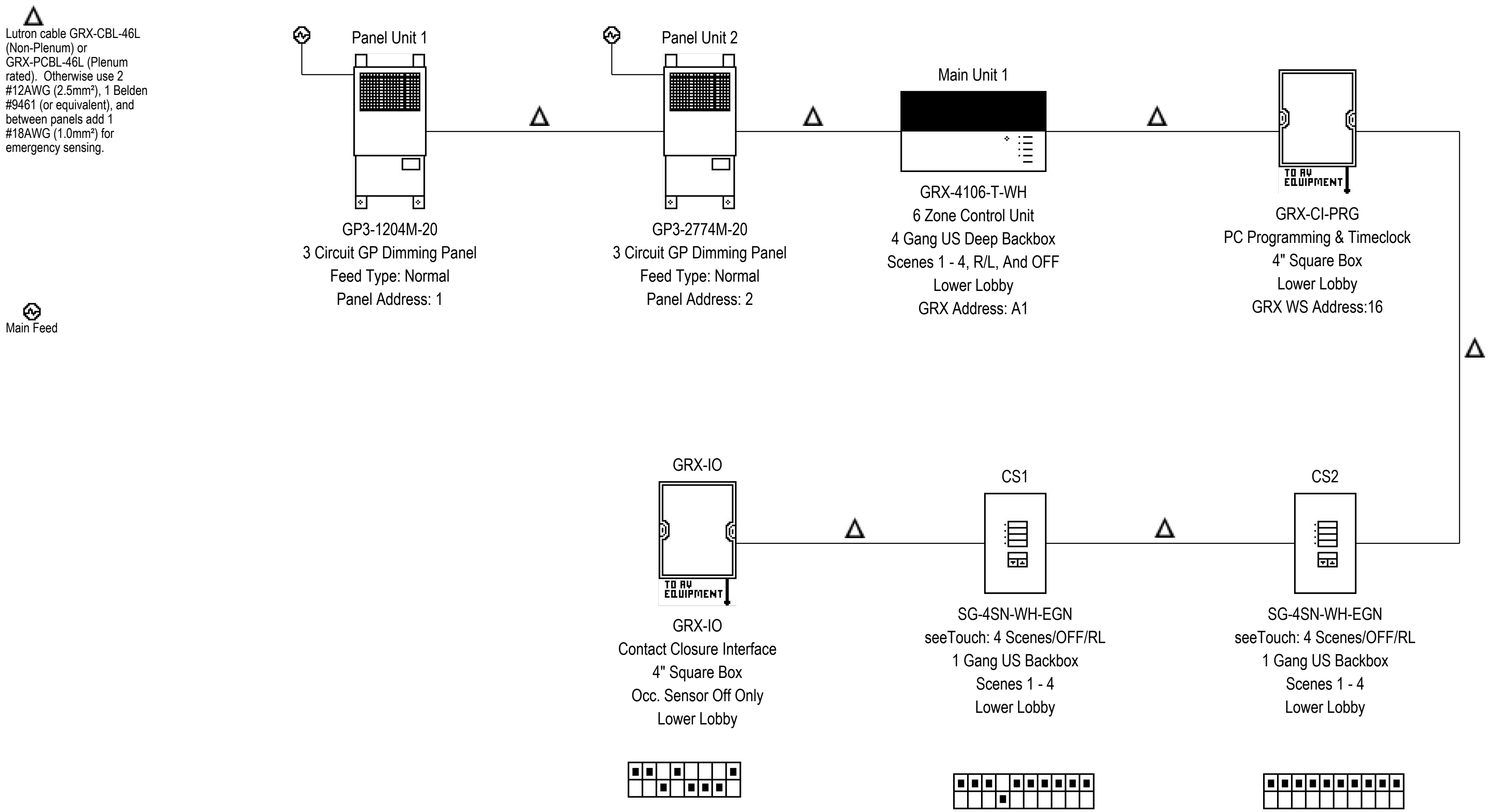
NEW DIMMER SHCEDULES

DP2H' DIMMING PANEL SCHEDULE

DP2H (Branch Breaker Type) 277V								
Zone	**Description**	**CKT. #**	**Fixture Type**	**Voltage**	**Load Type**	**Load(W) Per**	**Quantity**	**Total Load(W)**
a	North Row Linear Fluorescents	11(2LNH1)	FLUORESCENT	277V	Fluor - ECO-10	39	22	858
b	Middle Row Linear Fluorescents	13(2LNH1)	FLUORESCENT	277V	Fluor - ECO-10	39	33	1287
c	North Row Linear Fluorescents	14(2LNH1)	FLUORESCENT	277V	Fluor - ECO-10	39	18	702

DP2L' DIMMING PANEL SCHEDULE

DP2L (Branch Breaker Type) 120V								
Zone	**Description**	**CKT. #**	**Fixture Type**	**Voltage**	**Load Type**	**Load(W) Per**	**Quantity**	**Total Load(W)**
d	Café Wallwashers	1(2LNL1)	WALLWASHER	120V	HALOGEN	50	6	300
e	Café Pendants	2(2LNL1)	PENDANTS	120V	HALOGEN	50	5	250



LUTRON	**Project Name:** Senior Thesis 2009	**System:** New System 1
	Location: Union, NJ	**Design By:** John P Mulhern
www.lutron.com	**Project #:** Kean University	**Project Filename:** Lower Lobby.gdf
Toll Free: 800 523 9466	GRAFIK Eye Designer 7.1.124	**Date:** 9-Apr-2009 **Page:** 1 of 1

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

EXISTING PANELBOARD SCHEDULE

LOCATION:	ELEC. CLOSET 2-04A					REMARKS:							PANEL DESIGNATION: 2LNH1 (LIGHTING)
SERVICE:	277/480 VOLTS, 3 PHASE, 4 WIRE												
MAINS:	225 AMPS					MAIN OVERCURRENT PROTECTION:							
MOUNTING TYPE:	SURFACE					M.C.B.:							
GROUNDING:	GROUND BUS: YES ISOLATED GRD BUS: -					M.L.O.: YES POLES: 42							
	CONN. KVA								CONN. KVA				
SERVICE TO:	A	B	C	SIZE	NO.		NO.	SIZE	A	B	C	SERVICE TO:	
2ND FLR. - REST./MECH. RM. LTG.	0.58			20	1	-	2	20	1.67			2ND FLR. - AUDITORIUM LTG.	
2ND FLR. - MECH. LTG.		1.61		20	3		4	20		3.36		2ND FLR. - AUDITORIUM LTG.	
2ND FLR. - SUPP. SP./TOILET LTG.			1.55	20	5		6	20			2.59	2ND FLR. - AUDITORIUM LTG.	
2ND FLR. - CORR. LTG.	1.28			20	7	-	8	20	3.64			2ND FLR. - AUDITORIUM LTG.	
2ND FLR. - ELEV. LOBBY LTG.		2.22		20	9		10	20		3.96		2ND FLR. - EXHIBITION SPACE LTG.	
SPARE			-	20	11		12	20			3.65	2ND FLR. - EXHIBITION SPACE LTG.	
SPARE	-			20	13	-	14	20	-			SPARE	
SPARE		-		20	15		16	20		-		SPARE	
SPARE			-	20	17		18	20			-	SPARE	
SPARE	-			20	19	-	20	20	-			SPARE	
SPARE		-		20	21		22	20		-		SPARE	
SPARE			-	20	23		24	20			-	SPARE	
SPARE	-			20	25	-	26	20	-			SPARE	
SPARE		-		20	27		28	20		-		SPARE	
SPARE			-	20	29		30	20			-	SPARE	
SPARE	-			20	31	-	32	20	-			SPARE	
SPARE		-		20	33		34	20		-		SPARE	
SPARE			-	20	35		36	20			-	SPARE	
SPARE	-			20	37	-	38	20	-			SPARE	
SPARE		-		20	39		40	20		-		SPARE	
SPARE			-	20	41		42	20			-	SPARE	
SUBTOTALS	1.9	3.8	1.5						5.3	7.3	6.2		

TOTAL LOADS:	7.2	KVA PHASE A	15.0 A PHASE A	CONNECTED LOAD (PWR):		2.6 KVA
	11.1	KVA PHASE B	23.2 A PHASE B	DEMAND FACTOR (PWR):		80%
	7.8	KVA PHASE C	16.2 A PHASE C	CONNECTED LOAD (LTG):		23.5 KVA
				DEMAND FACTOR (LTG):		100%
				DEMAND LOAD:		25.6 KVA
TOTAL CONNECTED LOAD:	26.1	KVA		DEM. LOAD x 1.25	SPARE:	32.0 KVA
				AMP: (at 480 V)		39 A

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

NEW PANELBOARD SIZING WORKSHEET

'2LNH1' New Panel board Sizing Worksheet

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->					2LNH1	Panel Location:			ELEC CLOSET 2-04A		
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	fluorescent lighting	3	REST./MEC	580	w	0.95	580	611		
2	A	fluorescent lighting	3	- AUDITOR	1038.75	w	0.95	1039	1093		
3	B	fluorescent lighting	3	FLR. - MECH	1610	w	0.95	1610	1695		
4	B	fluorescent lighting	3	- AUDITOR	1512.42	w	0.95	1512	1592		
5	C	fluorescent lighting	3	SUPP. SP./	1550	w	0.95	1550	1632		
6	C	fluorescent lighting	3	- AUDITOR	831	w	0.95	831	875		
7	A	fluorescent lighting	3	FLR. - CORR	1280	w	0.95	1280	1347		
8	A	fluorescent lighting	3	- AUDITOR	349.02	w	0.95	349	367		
9	B	fluorescent lighting	3	- ELEV. LO	1688	w	0.95	1688	1777		
10	B	fluorescent lighting	3	EXHIBITION	3960	w	0.95	3960	4168		
11	C	fluorescent lighting	3	R. - LOWER	858	w	0.95	858	903		
12	C	fluorescent lighting	3	EXHIBITION	3650	w	0.95	3650	3842		
13	A	fluorescent lighting	3	R. - LOWER	1287	w	0.95	1287	1355		
14	A	fluorescent lighting	3	R. - LOWER	702	w	0.95	702	739		
15	B	fluorescent lighting	3	- AUDITOR	3545	w	0.95	3545	3732		
16	B	fluorescent lighting	3	- AUDITOR	357.5	w	0.95	358	376		
17	C	fluorescent lighting	3	- AUDITOR	347.12	w	1.00	347	347		
18	C	spare	3		3601	w	1.00	3601	3601		
19	A	spare	3		3601	w	1.00	3601	3601		
20	A	spare	3		3601	w	1.00	3601	3601		
21	B	spare	3		3601	w	1.00	3601	3601		
22	B	spare	3		3601	w	1.00	3601	3601		
23	C	spare	3		3601	w	1.00	3601	3601		
24	C	space			0	w		0	0		
25	A	space			0	w		0	0		
26	A	space			0	w		0	0		
27	B	spare			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	spare			0	w		0	0		
33	B	space			0	w		0	0		
34	B	space			0	w		0	0		
35	C	spare			0	w		0	0		
36	C	space			0	w		0	0		
37	A	space			0	w		0	0		
38	A	space			0	w		0	0		
39	B	space			0	w		0	0		
40	B	space			0	w		0	0		
41	C	space			0	w		0	0		
42	C	space			0	w		0	0		
PANEL TOTAL								46.8	48.1	Amps=	57.8
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					12.4	12.7	26%	45.9
PHASE TOTAL			B					19.9	20.5	43%	74.2
PHASE TOTAL			C					14.4	14.8	31%	53.4

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

NEW PANELBOARD LOAD CATEGORIES

<u>'2LNH1' New Panel board Load Categories</u>

LOAD CATAGORIES			Connected			Demand				Ver. 1.03
			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		46.8	48.1		46.8	48.1	0.97		
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						46.8	48.1			
Spare Capacity			45%			21.0	21.6			
Total Design Loads						67.8	69.7	0.97	Amps=	83.9

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

NEW PANELBOARD SCHEDULE

<u>'2LNH1' New Panel board Schedule</u>

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W SIZE/TYPE BUS: 100A SIZE/TYPE MAIN: 90A/3P C/B	PANEL TAG: 2LNH1 PANEL LOCATION: ELEC CLOSET 2-04A PANEL MOUNTING: SURFACE	MIN. C/B AIC: 10K OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 2LNH1

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
fluorescent lighting	- REST./MECH	580	20A/1P	1	*			2	20A/1P	1039	R. - AUDITORIU	fluorescent lighting
fluorescent lighting	FLR. - MECH.	1610	20A/1P	3		*		4	20A/1P	1512	LR. - AUDITORIU	fluorescent lighting
fluorescent lighting	- SUPP. SP./TC	1550	20A/1P	5			*	6	20A/1P	831	LR. - AUDITORIU	fluorescent lighting
fluorescent lighting	FLR. - CORR.	1280	20A/1P	7	*			8	20A/1P	349	LR. - AUDITORIU	fluorescent lighting
fluorescent lighting	R. - ELEV. LOB	1688	20A/1P	9		*		10	20A/1P	3960	- EXHIBITION SI	fluorescent lighting
fluorescent lighting	LR. - LOWER L	858	20A/1P	11			*	12	20A/1P	3650	- EXHIBITION SI	fluorescent lighting
fluorescent lighting	LR. - LOWER L	1287	20A/1P	13	*			14	20A/1P	702	FLR. - LOWER L	fluorescent lighting
fluorescent lighting	R. - AUDITORIU	3545	20A/1P	15		*		16	20A/1P	358	LR. - AUDITORIU	fluorescent lighting
fluorescent lighting	R. - AUDITORIU	347	20A/1P	17			*	18	20A/1P	3601	0	spare
spare	0	3601	20A/1P	19	*			20	20A/1P	3601	0	spare
spare	0	3601	20A/1P	21		*		22	20A/1P	3601	0	spare
spare	0	3601	20A/1P	23			*	24	20A/1P	0		space
space		0	20A/1P	25	*			26	20A/1P	0		space
spare		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		spare
space		0	20A/1P	33		*		34	20A/1P	0		space
spare		0	20A/1P	35			*	36	20A/1P	0		space
space		0	20A/1P	37	*			38	20A/1P	0		space
space		0	20A/1P	39		*		40	20A/1P	0		space
space		0	20A/1P	41			*	42	20A/1P	0		space

CONNECTED LOAD (KW) - A	12.44	TOTAL DESIGN LOAD (KW)	67.79
CONNECTED LOAD (KW) - B	19.87	POWER FACTOR	0.97
CONNECTED LOAD (KW) - C	14.44	TOTAL DESIGN LOAD (AMPS)	84

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

NEW FEEDER SIZING TABLE

<u>'2LNH1' Feeder Sizing Table</u>

<u>Breaker and Feeder Size</u>

FOR DESIGN AMPACITY OF 84 A

SELECT 90A/3P CIRCUIT BREAKER

(4) #4AWG & #8AWG GROUND WIRE

1-1/4" EMT CONDUIT

<u>Assumptions</u>

The panel was sized for 20 % spare capacity in case more lighting will be added in case the exhibition space needs more room. Because this panel only provides power for lighting loads, harmonics were an issue. An extra 25% was added to size the wire and the main circuit breaker in order to accommodate for the harmonics caused by fluorescent ballasts. There were not many spares provided because many luminaires can be placed on one circuit since this is a 480/277V panel board.

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

EXISTING PANELBOARD SCHEDULE

'2LNL1' Existing Panel board Schedule

LOCATION:	ELEC. CLOSET 2-04A	**REMARKS:**	**PANEL DESIGNATION:**
SERVICE:	277/480 **VOLTS, 3 PHASE, 4 WIRE**		**2LNL1**
MAINS:	400 **AMPS**	**MAIN OVERCURRENT PROTECTION:**	(RECEPT. & EQUIP.)
MOUNTING TYPE:		**M.C.B.: 250A**	
GROUNDING:	GROUND BUS: **YES** ISOLATED GRD BUS: -	**M.L.O.:**	
		POLES: 84	

SERVICE TO:	CONN. KVA A	CONN. KVA B	CONN. KVA C	SIZE	NO.		NO.	SIZE	CONN. KVA A	CONN. KVA B	CONN. KVA C	SERVICE TO:
2ND FLR. - AUDITORIUM LTG.	1.50			20	1	-	2	20	1.35			2ND FLR. - LOWER LOBBY SPACE LTG.
2ND FLR. - AUDITORIUM LTG.		1.50		20	3		4	20		1.53		2ND FLR. - LOWER LOBBY SPACE LTG.
2ND FLR. - AUDITORIUM LTG.			1.35	20	5		6	20			0.90	2ND FLR. - LOWER LOBBY SPACE LTG.
RECEPTION - UNDERCABINET LTG.	0.16			20	7	-	8	20	1.22			2ND FLR. - LOWER LOBBY SPACE LTG.
MECH.2-31/SHELL SP. RECEP. (3)		0.54		20	9		10	20		0.80		2ND FLR. - EXHIBITION SPACE LTG.
2ND FLR. - GEN'L RECEPT. (6)			1.08	20	11		12	20			1.62	2ND FLR. - EXHIBITION SPACE LTG.
TOILET/JAN. CLST. GFI REC. (3)	0.54			20	13	-	14	20	1.08			RECEP. - LCD TV'S/COMP (3)
EXHIBITION - WIRELESS PTS. (2)		0.96		20	15		16	20		1.26		RECEP LCD/EXHIB. COMP. (3)
EXHIB./PROJ. - WIRELESS/REC. (3)			1.20	20	17		18	20			0.96	AUD. - PODIUM/AV/ WIRELESS (3)
PROJECTION RECEPT. (3)	1.44			20	19	-	20	20	0.72			AUD. - PODIUM / AV(2)
AUDITORIUM - GEN'L RECEP. (5)		0.90		20	21		22	20		0.50		FUTURE PROJ. SCREEN (1)
AUDITORIUM - GEN'L RECEP. (5)			1.08	20	23		24	20			0.36	MECH. RM. 2-32 RECEPT. (2)
EF-5 (3/4 HP)	0.38			20	25	-	26	20	0.80			TERMINAL UNITS (4)
-		0.38			27		28	20		1.35		2ND FLR. - LOWER LOBBY SPACE LTG.
-			0.38	3P	29		30	20			-	SPARE
SPARE	-			20	31	-	32	20	-			SPARE
SPARE		-		20	33		34	20		-		SPARE
SPARE			-	20	35		36	20			-	SPARE
SPARE	-			20	37	-	38	20	-			SPARE
SPARE		-		20	39		40	20		-		SPARE
SPARE			-	20	41		42	20			-	SPARE
SPARE	-			20	43	-	44	20	-			SPARE
SPARE		-		20	45		46	20		-		SPARE
SPARE			-	20	47		48	20			-	SPARE
SPARE	-			20	49	-	50	20	-			SPARE
SPARE		-		20	51		52	20		-		SPARE
SPARE			-	20	53		54	20			-	SPARE
SPARE	-			20	55	-	56	20	-			SPARE
SPARE		-		20	57		58	20		-		SPARE
SPARE			-	20	59		60	20			-	SPARE
SPARE	-			20	61	-	62	20	-			SPARE
SPARE		-		20	63		64	20		-		SPARE
SPARE			-	20	65		66	20			-	SPARE
SPARE	-			20	67	-	68	20	-			SPARE
SPARE		-		20	69		70	20		-		SPARE
SPARE			-	20	71		72	20			-	SPARE
SPARE	-			20	73	-	74	20	-			SPARE
SPARE		-		20	75		76	20		-		SPARE
SPARE			-	20	77		78	20			-	SPARE
SPARE	-			20	79	-	80	20	-			SPARE
SPARE		-		20	81		82	20		-		SPARE
SPARE			-	20	83		84	20			-	SPARE
SUBTOTALS	4.0	4.3	5.1						5.2	5.4	3.8	

TOTAL LOADS:	9.2 **KVA PHASE A**	44.2 **A PHASE A**	**CONNECTED LOAD (PWR):**		15.9 KVA
	9.7 **KVA PHASE B**	46.8 **A PHASE B**	**DEMAND FACTOR (PWR):**		80%
	8.9 **KVA PHASE C**	43.0 **A PHASE C**	**CONNECTED LOAD (LTG):**		11.9 KVA
			DEMAND FACTOR (LTG):		100%
			DEMAND LOAD:		24.7 KVA
TOTAL CONNECTED LOAD:	27.8 **KVA**		**DEM. LOAD x** 1.25	**SPARE:**	30.8 KVA
			AMP: (at 208 V)		86 A

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

NEW PANELBOARD SIZING WORKSHEET

.

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->					2LNL1	Panel Location:		Elec Closet 2-13			
Nominal Phase to Neutral Voltage------->					120	Phase:		3			
Nominal Phase to Phase Voltage-------->					208	Wires:		4			
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA		Remarks
1	A	Café Wall Wash Lts.	5	Lobby	300	w	1.00	300	300		
2	A	Café Pendant Lts.	5	Lobby	250	w	1.00	250	250		
3	B	Track Lighting	4	Lobby	342	va	0.90	380	422		
4	B	Track Lighting	1	Auditorium	1066.45	w	0.90	1066	1185		
5	C	Spare	1		1560	w	1.00	1560	1560		
6	C	Spare	1		1560	w	1.00	1560	1560		
7	A	Fluorescent Ltg	3	Reception	160	w	0.95	160	168		
8	A	Spare	1		1560	w	1.00	1560	1560		
9	B	Gen. Load Recept.	1	ech 2-31/Sh	540	va	0.85	635	747		
10	B	Fluorescent Ltg	3	Exhb. Ltg.	800	w	0.95	800	842		
11	C	Gen. Load Recept.	1	2nd Flr.	1080	va	0.85	1271	1495		
12	C	Fluorescent Ltg	3	Exhibition	1620	w	0.95	1620	1705		
13	A	GFI Receps.	1	oilet/Jan. Cls	540	va	0.85	635	747		
14	A	LCD TV's/Comps	1	Reception	1080	va	0.85	1271	1495		
15	B	Wireless Pts.	1	Exhibiton	960	va	0.85	1129	1329		
16	B	Computers	1	Reception	1260	va	0.85	1482	1744		
17	C	Wireless Pts.	1	khb./Proj. Rr	1200	va	0.85	1412	1661		
18	C	Podium AV/Wless.	1	Auditorium	960	va	0.85	1129	1329		
19	A	Gen. Load Recept.	1	rojection Rr	1440	va	0.85	1694	1993		
20	A	Podium AV.	1	Auditorium	720	va	0.85	847	997		
21	B	Gen. Load Recept.	1	Auditorium	900	va	0.85	1059	1246		
22	B	Fut. Proj. Screen	1	Auditorium	500	va	0.85	588	692		
23	C	Gen. Load Recept.	1	Auditorium	1080	va	0.85	1271	1495		
24	C	Gen. Load Recept.		Mech 2-32	360	va	0.85	424	498		
25	A	EF-5	6		0.25	hp	0.90	250	278		
26	A	Spare	1		1560	w	1.00	1560	1560		
27	B	EF-5	6		0.25	hp	0.90	250	278		
28	B	Spare	1		1560	w	1.00	1560	1560		
29	C	EF-5	6		0.25	hp	0.90	250	278		
30	C	Spare	1		1560	w	1.00	1560	1560		
31	A	spare	1		1560	w	1.00	1560	1560		
32	A	spare			0	w	1.00	0	0		
33	B	spare			0	w	1.00	0	0		
34	B	spare			0	w	1.00	0	0		
35	C	spare			0	w	1.00	0	0		
36	C	spare			0	w	1.00	0	0		
37	A	space			0	w	1.00	0	0		
38	A	space			0	w	1.00	0	0		
39	B	space			0	w	1.00	0	0		
40	B	space			0	w	1.00	0	0		
41	C	space			0	w	1.00	0	0		
42	C	space			0	w	1.00	0	0		
PANEL TOTAL								31.1	34.1	Amps=	94.7
PHASE LOADING							kW	kVA	% Total	Amps	% +/-
PHASE TOTAL			A				10.1	10.9	32%	90.9	-4.02%
PHASE TOTAL			B				9.0	10.0	29%	83.7	-11.61%
PHASE TOTAL			C				12.1	13.1	39%	109.5	15.63%

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

NEW PANELBOARD LOAD CATEGORIES

‘2LNL1’ New Panel board Load Categories

LOAD CATAGORIES			Connected			Demand				
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		26.4	29.1	0.70	18.5	20.4	0.91		
2	computers		0.0	0.0	0.90	0.0	0.0			
3	fluorescent lighting		2.6	2.7	1.00	2.6	2.7	0.95		
4	HID lighting		0.4	0.4	1.00	0.4	0.4	0.90		
5	incandescent lighting		0.6	0.6	1.00	0.6	0.6	1.00		
6	HVAC fans		0.8	0.8	0.80	0.6	0.7	0.90		
7	heating		0.0	0.0	1.25	0.0	0.0			
8	kitchen equipment		0.0	0.0	0.80	0.0	0.0			
Total Demand Loads						22.6	24.7			
Spare Capacity			50%			11.3	12.4			
Total Design Loads						33.9	37.1	0.91	Amps=	102.9

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

NEW PANELBOARD SCHEDULE

<u>'2LNL1' New Panel board Schedule</u>

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 125A/3P C/B

PANEL TAG: 2LNL1
PANEL LOCATION: Elec Closet 2-13
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Café Wall Wash Lts.	Lobby	300	20A/1P	1	*			2	20A/1P	250	Lobby	Café Pendant Lts.
Track Lighting	Lobby	380	20A/1P	3		*		4	20A/1P	1066	Auditorium	Track Lighting
Spare	0	1560	20A/1P	5			*	6	20A/1P	1560	0	Spare
Fluorescent Ltg	Reception	160	20A/1P	7	*			8	20A/1P	1560	0	Spare
Gen. Load Recept.	Mech 2-31/Shel	635	20A/1P	9		*		10	20A/1P	800	Exhb. Ltg.	Fluorescent Ltg
Gen. Load Recept.	2nd Flr.	1271	20A/1P	11			*	12	20A/1P	1620	Exhibition	Fluorescent Ltg
GFI Receps.	Toilet/Jan. Clst.	635	20A/1P	13	*			14	20A/1P	1271	Reception	LCD TV's/Comps
Wireless Pts.	Exhibiton	1129	20A/1P	15		*		16	20A/1P	1482	Reception	Computers
Wireless Pts.	Exhb./Proj. Rms	1412	20A/1P	17			*	18	20A/1P	1129	Auditorium	Podium AV/Wless.
Gen. Load Recept.	Projection Rm.	1694	40A/3P	19	*			20	20A/1P	847	Auditorium	Podium AV.
Gen. Load Recept.	Auditorium	1059	^	21		*		22	20A/1P	588	Auditorium	Fut. Proj. Screen
Gen. Load Recept.	Auditorium	1271	^	23			*	24	20A/1P	424	Mech 2-32	Gen. Load Recept.
EF-5	0	250	20A/3P	25	*			26	20A/1P	1560	0	Spare
EF-5	0	250	20A/3P	27		*		28	20A/1P	1560	0	Spare
EF-5	0	250	20A/3P	29			*	30	20A/1P	1560	0	Spare
spare	0	1560	20A/1P	31	*			32	20A/1P	0		spare
spare		0	20A/1P	33		*		34	20A/1P	0		spare
spare		0	20A/1P	35			*	36	20A/1P	0		spare
space		0	20A/1P	37	*			38	20A/1P	0		space
space		0	20A/1P	39		*		40	20A/1P	0		space
space		0	20A/1P	41			*	42	20A/1P	0		space

CONNECTED LOAD (KW) - A	10.09	TOTAL DESIGN LOAD (KW)	33.90
CONNECTED LOAD (KW) - B	8.95	POWER FACTOR	0.91
CONNECTED LOAD (KW) - C	12.06	TOTAL DESIGN LOAD (AMPS)	103

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

NEW FEEDER SIZING TABLE

‘2LNL1’ New Feeder Sizing Table

Breaker and Feeder Size

FOR DESIGN AMPACITY OF 103A

SELECT 125A/3P CIRCUIT BREAKER

(4) #2AWG & #6AWG GROUND WIRE

1-1/4” EMT CONDUIT

Assumptions

The panel was sized for 50 % spare capacity in case more power will be needed for equipment or general receptacle loads. This was done due to the fact that the panel was sized for a very small ampacity. The restaurant shell already has a 400A connection for the future, so this panel does not need to take into account that future load. There were some spares provided for the future use.

V. ELECTRICAL DEPTH

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C) OUTDOOR SPACE REDESIGN

INTRODUCTION

Design Concept

The new lighting will incorporate luminaires that reflect the architectural style of this building. The luminaire chosen is a bollard fixture manufactured by Bega. This luminaire is a small bollard unlike the old design with large pole mounted fixtures. The silver finish complements the mullions of curtain wall around the building. A time clock will turn on the lights at a set time at night.

The staggered layout as suggested in the schematic design did not work out. The distribution of light on the pathway was aesthetically unpleasing. The fixtures were placed across from each other at a 10’ typical spacing along the pathway.

The portico area continues the recessed theme with recessed metal halide down lights for general illuminance and metal halide wall washers to accent the architectural statement of the west stairwell corridor walls. An attempt was made to uplight the columns, but since they were flush against the façade, spill light caused unsightly reflections farther up the building. The down lights will back light the columns giving the portico depth from a distance while providing illuminance for security as well.

Fixture Mounting

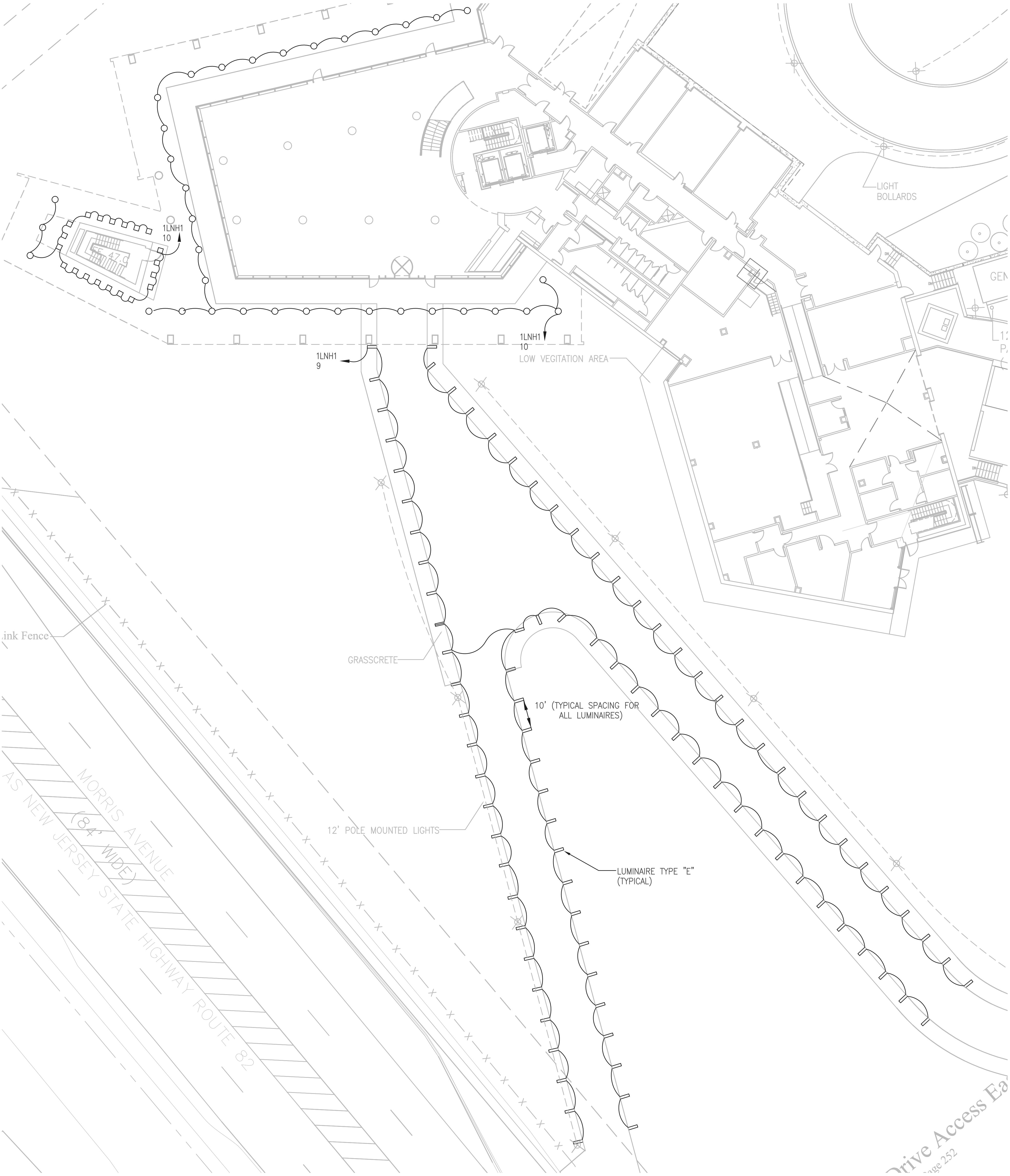
The fixture will be anchored into the ground. The grasscrete surface will require holes in order to anchor the luminaires. The luminaires will be placed on the edge of the grasscrete right before the concrete pathway. The other two fixtures will be recessed into outdoor gypsum wall board ceiling.

V. ELECTRICAL DEPTH

C) OUTDOOR SPACE REDESIGN

CRITERIA/CONTROLS

The main criterion for the outdoor space was energy efficient lighting. No expensive controls were required for this space. The lights go through a time clock which turns them off at a predetermined hour. Pole mounted fixtures were not used for the pathway to change the design to a greater extent. Low wattage metal halides were able to be used cause of the tall ceiling height. The exterior wall of the western stairwell corridor needed to be highlighted to make its irregular architectural form stands out.



LIGHT BOLLARDS
1LNH1
10
1LNH1
10
1LNH1
9
LOW VEGITATION AREA
GEN
GRASSCRETE
10' (TYPICAL SPACING FOR ALL LUMINAIRES)
12' POLE MOUNTED LIGHTS
LUMINAIRE TYPE "E" (TYPICAL)
Link Fence
MORRIS AVENUE
(84' WIDE)
AS NEW JERSEY STATE HIGHWAY ROUTE 82
Drive Access Ea

V. ELECTRICAL DEPTH

C) OUTDOOR SPACE REDESIGN

EXISTING PANELBOARD SCHEDULE

‘1LNH1’ Existing Panel board Schedule

LOCATION: NORM. ELEC. SVCE. RM. 1-31
SERVICE: 277/480 **VOLTS**, 3 **PHASE**, 4 **WIRE**
MAINS: 100 **AMPS**
MOUNTING TYPE: SURFACE
GROUNDING: GROUND BUS: **YES**
ISOLATED GRD BUS: -

REMARKS:

MAIN OVERCURRENT PROTECTION:
M.C.B.: -
M.L.O.: **YES**
POLES: 42

PANEL DESIGNATION:
1LNH1
(LIGHTING)

SERVICE TO:	CONN. KVA A	CONN. KVA B	CONN. KVA C	SIZE	NO.		NO.	SIZE	CONN. KVA A	CONN. KVA B	CONN. KVA C	SERVICE TO:
1ST FLR. - RESTAURANT LTG.	1.36			20	1	-	2	20	1.58			1ST FLR. - TOILET LTG.
1ST FLR. - LOBBY LTG.		0.37		20	3		4	20		2.49		1ST FLR. - CLASSRM./LAB LTG.
1ST FLR. - CORRIDOR LTG.			3.13	20	5		6	20			0.70	1ST FLR. - EXTERIOR LTG.
1ST FLR. - MECH. RM. LTG.	2.85			20	7	-	8	20	-			SPARE
EXTERIOR LTG.		1.31		20	9		10	20		-		SPARE
EXTERIOR LTG.			1.33	20	11		12	20			-	SPARE
SPARE	-			20	13	-	14	20	-			SPARE
SPARE		-		20	15		16	20		-		SPARE
SPARE			-	20	17		18	20			-	SPARE
SPARE	-			20	19	-	20	20	-			SPARE
SPARE		-		20	21		22	20		-		SPARE
SPARE			-	20	23		24	20			-	SPARE
SPARE	-			20	25	-	26	20	-			SPARE
SPARE		-		20	27		28	20		-		SPARE
SPARE			-	20	29		30	20			-	SPARE
SPARE	-			20	31	-	32	20	-			SPARE
SPARE		-		20	33		34	20		-		SPARE
SPARE			-	20	35		36	20			-	SPARE
SPARE	-			20	37	-	38	20	-			SPARE
SPARE		-		20	39		40	20		-		SPARE
SPARE			-	20	41		42	20			-	SPARE
SUBTOTALS	4.2	1.7	4.5						1.6	2.5	0.7	

TOTAL LOADS:	5.8 **KVA PHASE A**	12.0 **A PHASE A**	**CONNECTED LOAD (PWR):**			0.0 KVA
	4.2 **KVA PHASE B**	8.7 **A PHASE B**	**DEMAND FACTOR (PWR):**			80%
	5.2 **KVA PHASE C**	10.7 **A PHASE C**	**CONNECTED LOAD (LTG):**			15.1 KVA
			DEMAND FACTOR (LTG):			100%
			DEMAND LOAD:			15.1 KVA
TOTAL CONNECTED LOAD:	15.1 **KVA**		**DEM. LOAD x**	1.25	**SPARE:**	18.9 KVA
			AMP: **(at**	480	**V)**	23 A

V. ELECTRICAL DEPTH

C) OUTDOOR SPACE REDESIGN

NEW PANELBOARD SIZING WORKSHEET

‘1LNH1’ New Panel board Sizing Worksheet

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->					1LNH1	Panel Location:			NORMAL SRVC ELEC 1-31		
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	fluorescent lighting	3	ESTAURAN	1360	va	0.95	1432	1507		
2	A	fluorescent lighting	3	LR. - TOILE	1580	va	0.95	1663	1751		
3	B	fluorescent lighting	3	R. - LOWER	370	va	0.95	389	410		
4	B	fluorescent lighting	3	R. - CLASSR	2490	va	0.95	2621	2759		
5	C	fluorescent lighting	3	LR. - CORR	3130	va	0.95	3295	3468		
6	C	HID lighting	4	EXTERIOR	700	va	0.85	824	969		
7	A	fluorescent lighting	3	LR. - MECH	2850	va	0.95	3000	3158		
8	A	HID lighting	4	EXTERIOR	575	va	0.85	676	796		
9	B	HID lighting	4	EXTERIOR	2913	va	0.85	3427	4032		
10	B	HID lighting	4	EXTERIOR	800	va	0.85	941	1107		
11	C	HID lighting	4	EXTERIOR	1330	va	0.85	1565	1841		
12	C	spare	3		3545	va	0.90	3939	4377		
13	A	spare	3		3545	va	0.90	3939	4377		
14	A	spare	3		3545	va	0.90	3939	4377		
15	B	spare	3		3545	va	0.90	3939	4377		
16	B	spare	3		3545	va	0.90	3939	4377		
17	C	spare	3		3545	va	0.90	3939	4377		
18	C	space				va	0.85	0	0		
19	A	space				w	1.00	0	0		
20	A	space				w	1.00	0	0		
21	B	space				w	1.00	0	0		
22	B	space				w	1.00	0	0		
23	C	space				w	1.00	0	0		
24	C	space				w	1.00	0	0		
25	A	space				w	0.95	0	0		
26	A	space				w	0.95	0	0		
27	B	space				w	0.95	0	0		
28	B	space				hp	0.90	0	0		
29	C	space				hp	0.90	0	0		
30	C	space				hp	0.90	0	0		
31	A	space				w	1.00	0	0		
32	A	space				w	1.00	0	0		
33	B	space				w	1.00	0	0		
34	B	space				w	1.00	0	0		
35	C	space				w	1.00	0	0		
36	C	space				w	1.00	0	0		
37	A	space				w	1.00	0	0		
38	A	space				w	1.00	0	0		
39	B	space				w	1.00	0	0		
40	B	space				w	1.00	0	0		
41	C	space				w	1.00	0	0		
42	C	space				w	1.00	0	0		
PANEL TOTAL								43.5	48.1	Amps=	57.8
PHASE LOADING							kW	kVA	% Total	Amps	% +/-
		PHASE TOTAL	A				14.6	16.0	33%	57.6	-0.34%
		PHASE TOTAL	B				15.3	17.1	36%	61.6	6.51%
		PHASE TOTAL	C				13.6	15.0	31%	54.3	-6.17%

V. ELECTRICAL DEPTH

C) OUTDOOR SPACE REDESIGN

NEW PANELBOARD LOAD CATEGORIES

‘1LNH1’ New Panel board Load Categories

LOAD CATAGORIES			Connected			Demand				
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0	0.70	0.0	0.0			
2	computers		0.0	0.0	0.90	0.0	0.0			
3	fluorescent lighting		36.0	39.3	1.00	36.0	39.3	0.92		
4	HID lighting		7.4	8.7	1.00	7.4	8.7	0.85		
5	incandescent lighting		0.0	0.0	1.00	0.0	0.0			
6	HVAC fans		0.0	0.0	0.80	0.0	0.0			
7	heating		0.0	0.0	1.25	0.0	0.0			
8	kitchen equipment		0.0	0.0	0.80	0.0	0.0			
Total Demand Loads						43.5	48.1			
Spare Capacity			45%			19.6	21.6			
Total Design Loads						63.0	69.7	0.90	Amps=	83.9

V. ELECTRICAL DEPTH

C) OUTDOOR SPACE REDESIGN

NEW PANELBOARD SCHEDULE

<u>'1LNH1' New Panel board Schedule</u>

PANELBOARD SCHEDULE

VOLTAGE: 480Y/208V,3PH,4W	PANEL TAG: 1LNH1	MIN. C/B AIC: 22K
SIZE/TYPE BUS: 100A	PANEL LOCATION: NORMAL SRVC ELEC 1-31	OPTIONS: PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN: 90A/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
fluorescent lighting	RESTAURANT	1432	20A/1P	1	*			2	20A/1P	1663	FLR. - TOILET	fluorescent lighting
fluorescent lighting	LR. - LOWER L	389	20A/1P	3		*		4	20A/1P	2621	FLR. - CLASSRM	fluorescent lighting
fluorescent lighting	FLR. - CORRID	3295	20A/1P	5			*	6	20A/1P	824	EXTERIOR	HID lighting
fluorescent lighting	FLR. - MECH.	3000	20A/1P	7	*			8	20A/1P	676	EXTERIOR	HID lighting
HID lighting	EXTERIOR	3427	20A/1P	9		*		10	20A/1P	941	EXTERIOR	HID lighting
HID lighting	EXTERIOR	1565	20A/1P	11			*	12	20A/1P	3939	0	spare
spare	0	3939	20A/1P	13	*			14	20A/1P	3939	0	spare
spare	0	3939	20A/1P	15		*		16	20A/1P	3939	0	spare
spare	0	3939	20A/1P	17			*	18	20A/1P	0	0	space
space	0	0	20A/1P	19	*			20	20A/1P	0	0	space
space	0	0	20A/1P	21		*		22	20A/1P	0	0	space
space	0	0	20A/1P	23			*	24	20A/1P	0	0	space
space	0	0	20A/1P	25	*			26	20A/1P	0	0	space
space	0	0	20A/1P	27		*		28	20A/1P	0	0	space
space	0	0	20A/1P	29			*	30	20A/1P	0	0	space
space		0	20A/1P	31	*			32	20A/1P	0		space
space		0	20A/1P	33		*		34	20A/1P	0		space
space		0	20A/1P	35			*	36	20A/1P	0		space
space		0	20A/1P	37	*			38	20A/1P	0		space
space		0	20A/1P	39		*		40	20A/1P	0		space
space		0	20A/1P	41			*	42	20A/1P	0		space

CONNECTED LOAD (KW) - A	14.65	TOTAL DESIGN LOAD (KW)	63.03
CONNECTED LOAD (KW) - B	15.26	POWER FACTOR	0.90
CONNECTED LOAD (KW) - C	13.56	TOTAL DESIGN LOAD (AMPS)	84

V. ELECTRICAL DEPTH

C) OUTDOOR SPACE REDESIGN

NEW FEEDER SIZING TABLE

‘1LNH1’ Feeder Sizing Table

Breaker and Feeder Size

FOR DESIGN AMPACITY OF 83.9 A

SELECT PANEL WITH 100A BUS RATING

SELECT 90A/3P CIRCUIT BREAKER

(4) #4AWG & #8AWG GROUND WIRE

1-1/4” EMT CONDUIT

Assumptions

The panel was sized for 20 % spare capacity in case more lighting will be added in on the first floor or to the exterior. Because this panel only provides power for lighting loads, harmonics were an issue. An extra 25% was added to size the wire and the main circuit breaker in order to accommodate for the harmonics caused by fluorescent ballasts. There were not many spares provided because many luminaires can be placed on one circuit since this is a 480/277V panel board.

V. ELECTRICAL DEPTH

D) AUDITORIUM REDESIGN

INTRODUCTION

Description of Space

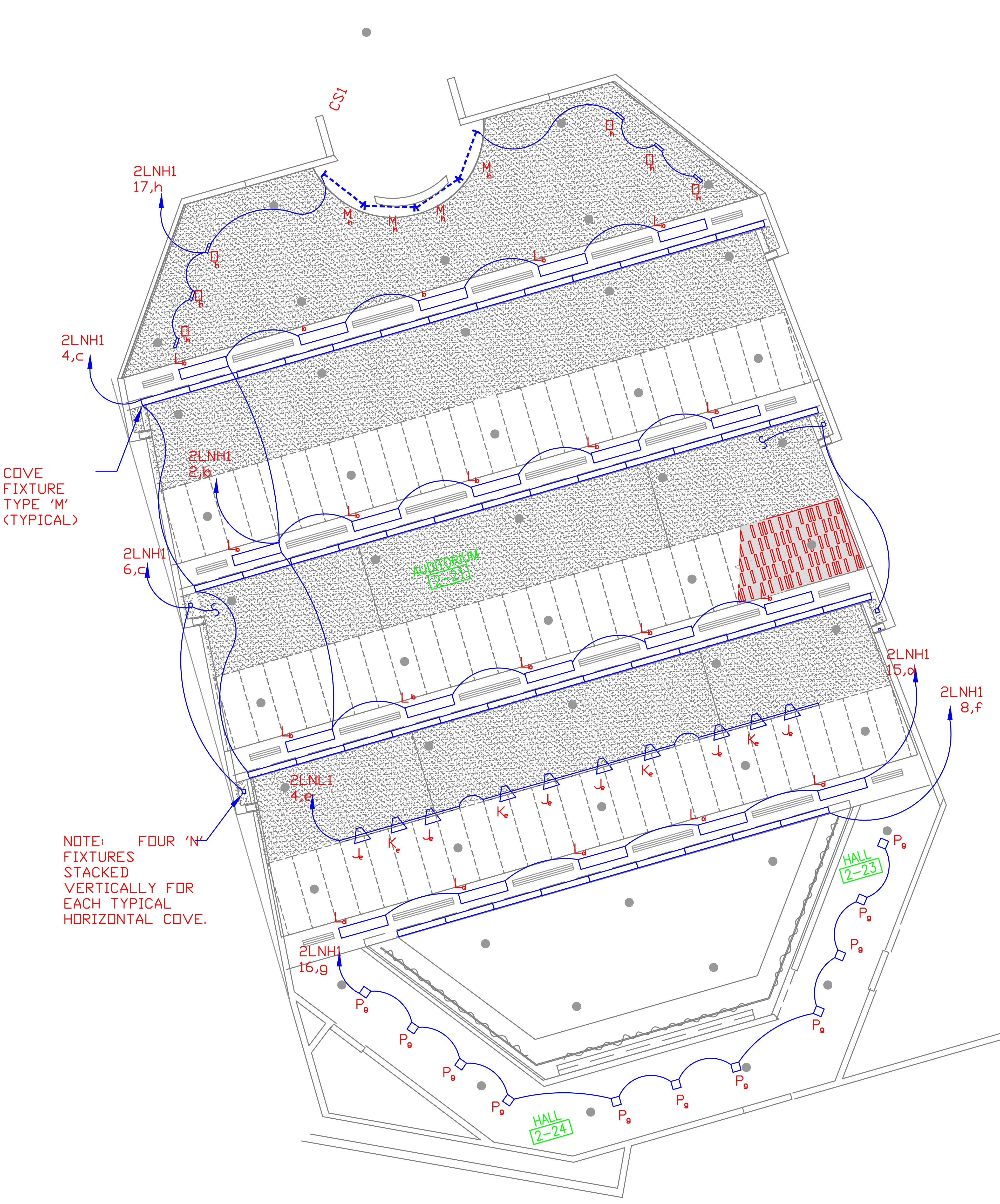
This lecture hall has approximately 280 students with fold out desks. The ceiling has multiple slopes with heights ranging from 8', 10', 11.5', 12', and 12.5'. It has a jagged shape when viewed in section. There are three sections of seats with two aisles. There is a stage area where most likely a teacher will have a desk onto which he or she will place his belongings. The walls are made of acoustic material for sound absorption to prevent echoes. The walls have a jagged shape in plan for acoustic reflections. The floors are made of carpet with a rubber base underneath. There is also a projector room which will house the projector and controls for presentations.

Design Concept

The new lighting design theme for this space is inspired by a circuit board. A circuit board is almost flat with linear strips of light. This concept was translated into this space by providing only recessed and semi recessed lighting in order to have a clean appearance for the ceiling. This design is intended to achieve a subjective impression of visual clarity by providing uniform illumination onto the task plane. The whiteboard will have a higher luminance than the lateral walls so that students will concentrate on it during class.

Fixture Mounting

The main luminaires chosen were both 1' x 4' linear fluorescents. However the wall washers are semi recessed and the stage lighting is track mounted. The wall washers will be cut into the tile and mounted in a semi recessed fashion. The fixtures for general illumination are recessed mounted between diffusers. There is a continuous cove above these fixtures which lights the ceiling



AUDITORIUM LIGHTING RCP DIAGRAM

SUBMITTED FOR PROF. DANNERTH APRIL 7, 2009

NEW JERSEY CENTER FOR SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION

AE 482W JOHN MULHERN

V. ELECTRICAL DEPTH

B) AUDITORIUM REDESIGN

CRITERIA/CONTROLS

Controls will be absolutely necessary for this space because it will require flexibility for the lighting. The first scene will be for a normal class mode. The other scene is for a presentation mode on the projector screen. Finally a third mode will require track lighting for events on the stage. Also energy efficient fluorescent lighting is utilized for most of the space. The auditorium lighting will be powered by "2LNH1", and the track will be powered by '2LNL1" , the 120V panel.

This space will be controlled by a GRAFIK Eye system made by Lutron. The luminaires will be grouped into 8 zones. The zones are based on the linear runs of the fluorescents. The auditorium will be wired similar to the lower lobby as an example. It will receive its own 277V dimming panel. The only difference would be is that there are more zones this time requiring a larger dimming power panel, but the control unit remains the same size. The track would go onto 'DP2L' causing a resize to a four zone power panel.

V. ELECTRICAL DEPTH

B) LOWER LOBBY REDESIGN

EXISTING PANELBOARD SCHEDULE

SEE LOWER LOBBY PANEL REDESIGN

V. ELECTRICAL DEPTH

E) ALUMINUM FEEDERS VS. COPPER FEEDERS

INTRODUCTION

The NJCFSTME Building's electrical system has numerous switchboards and branch panels on every floor. This is due to the fact that there are normal, emergency, standby, and optional standby branches. There are 73 panels scattered throughout the building and 117 major feeders including the secondary side of all the step down transformer. A cost estimate was conducted to see whether the savings from substituting copper feeders with aluminum ones was worth the hassle of using aluminum.

ASSUMPTIONS

For this depth the assumed conduit type for all runs was EMT because this conduit is mostly used throughout interiors of university buildings. The conduits for feeders on the upper floors were assumed to be run in the ceiling. An engineer cannot tell how many conduits can be placed in a slab by an electrician. The slabs of upper floors cannot provide 3" of cover on top required by the NEC in many instances.

The assumed wire type was THHN/THWN. The RS Means 2009 text does not offer aluminum THHN/THWN estimate values. However upon inspection, THW copper had the same prices for labor and material as THHN/THWN, so THW aluminum pricing values were used to perform this estimate. No bend or elbow pricing was incorporated into this estimate because they would have to be performed regardless of wire type. Also copper prices were used for feeders smaller than #6 AWG because RS Means does not list information for aluminum conductors below this size.

CONCLUSIONS

After comparing price differences, it is apparent that substituting the copper feeders for aluminum is not worth the savings of approximately $120,000. The design of the system causes savings to seem less than expected. Power is distributed throughout the building on a 480Y/277V system. There are electrical rooms on every floor not to mention two aluminum bus duct risers which saves cost on the feeder runs. The distribution panel, step down transformer, and most branch panels are located in the same electrical room which decreases feeder length. All these factors cause runs to be shorter, which saves on feeder costs. With all the hassle for electricians with using aluminum, this option is not worth the savings.

COPPER FEEDER SCHEDULE

TAG	FROM	TO	NO. OF SETS	CONDUIT (PER SET) SIZE	CONDUIT (PER SET) TYPE	CONDUCTORS (PER SET) PHASE CONDUCTORS No.	PHASE SIZE	PHASE TYPE	NEUTRAL CONDUCTORS No.	NEUTRAL SIZE	NEUTRAL TYPE	GROUND CONDUCTORS No.	GROUND SIZE	GROUND TYPE	SIZE OF OCP	FRAME OR SWITCH SIZE	LENGTH	TOTAL CNDTR/CDUIT LENGTH W/ SETS	GROUND LENGTH
E1	EGS-1	1SWBDG1	3	4	PVC	3	400KCMIL	CU THWN	1	400KCMIL	CU THWN	1	2/0	CU THWN	--	--		0	0
E2	1SWBDG1	LOAD BANK	3	?	PVC	3	600KCMIL	CU THWN	1	600KCMIL	CU THWN	1	1/0	CU THWN	1200	1600		0	0
E3	1SWBDG1	1LVSG1	3	4"	PVC	3	600KCMIL	CU THWN	1	600KCMIL	CU THWN	1	1/0	CU THWN	1000	1600	171	684	171
E4	1SWBDG1	FIRE PUMP	1	2	PVC	3	1/0	CU THWN	--	--	CU THWN	1	6AWG	CU THWN	150	400	168	672	168
E5	1LVSG1	1ASTE1	1	2-1/2"	PVC	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	1600	15	60	15
E6	1ASTE1	1PEH1	1	2-1/2"	PVC	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	--	--	24	96	24
E7	1PEH1	2T2	1	3/4"	EMT	3	10AWG	CU THWN	--	--	--	--	--	--	30	30	156.5	469.5	156.5
E8	1PEH1	1T3	1	1	EMT	3	4AWG	CU THWN	--	--	--	--	--	--	70	100	15	45	15
E9	1PEH1	6T2	1	3/4"	EMT	3	10AWG	CU THWN	--	--	--	--	--	--	30	30	215.5	646.5	215.5
E10	1PEH1	1LEH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	9	36	9
E11	1PEH1	2LEH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	162.5	650	162.5
E12	1PEH1	4LEH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	6AWG	CU THWN	150	200	197.5	790	197.5
E13	2T2	2LEL1	1	1-1/4"	EMT	3	6AWG	CU THWN	1	6AWG	CU THWN	1	6AWG	CU THWN	60	60	5.5	22	5.5
E14	1T3	1LEL1	1	1-1/2"	PVC	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	125	200	68	272	68
E15	6T2	6LEL1	1	1-1/4"	EMT	3	6AWG	CU THWN	1	6AWG	CU THWN	1	6AWG	CU THWN	60	60		0	0
E16	2LEH1	3LEH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	--	--	16	64	16
E17	4LEH1	5LEH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	6AWG	CU THWN	--	--	4.5	18	4.5
E18	5LEH1	6LEH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	6AWG	CU THWN	--	--	22	88	22
N1	1USSHV1	1PBP1	4	3	EMT	3	350KCMIL	CU THWN	1	350KCMIL	CU THWN	1	3/0	CU THWN	1200	1200	1078	4312	1078
N2	1USSHV1	1PNH1	2	3	EMT	3	350KCMIL	CU THWN	1	350KCMIL	CU THWN	1	1/0	CU THWN	600	600	133.5	534	133.5
N3	1USSHV1	2PNH1	2	3	EMT	3	350KCMIL	CU THWN	1	350KCMIL	CU THWN	1	1/0	CU THWN	600	600	457.5	1830	457.5
N4	1USSHV1	1PNH2	3	3	EMT	3	300KCMIL	CU THWN	1	300KCMIL	CU THWN	1	1/0	CU THWN	800	800	378	1512	378
N5	1USSHV1	1PNH3	3	3	EMT	3	300KCMIL	CU THWN	1	300KCMIL	CU THWN	1	1/0	CU THWN	800	800	435	1740	435
N6	1USSHV1	1PNH4	3	3	EMT	3	300KCMIL	CU THWN	1	300KCMIL	CU THWN	1	1/0	CU THWN	800	800	426	1704	426
N7	1USSHV1	FUTURE	2	2	EMT	3	3/0	CU THWN	1	3/0	CU THWN	1	2AWG	CU THWN	400	400		0	0
N8	1USSHV1	CHILLER #1	1	4	EMT	3	500KCMIL	CU THWN	1	500KCMIL	CU THWN	1	2AWG	CU THWN	350	400	100.5	402	100.5
N9	1USSHV1	1ATSE1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	48.5	194	48.5
N10	1USSHV1	1ATSS1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	47	188	47
N11	1USSHV1	1ATSS2	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	51	204	51
N12	1USSHV1	1ATSO1	2	3	EMT	3	350KCMIL	CU THWN	1	350KCMIL	CU THWN	1	1/0	CU THWN	600	600	104	416	104
N13	1PNH1	1T2	1	1-1/4"	EMT	3	2AWG	CU THWN	--	--	--	--	--	--	225	225	10.5	31.5	10.5
N14	1PNH1	1T1	1	1-1/4"	EMT	3	2AWG	CU THWN	--	--	--	--	--	--	90	100	14	42	14
N15	1PNH1	2T1	1	1-1/2"	EMT	3	1/0	CU THWN	--	--	--	--	--	--	150	200	59.5	178.5	59.5
N16	1PNH1	2LNH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	6AWG	CU THWN	150	200	72.5	290	72.5
N17	1PNH1	1LNH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	14.5	58	14.5
N18	1T2	1LNL2	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	150	200	66	264	66
N19	1T1	1LNL1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	150	200	10.5	42	10.5
N20	2T1	2LNL1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	12.5	50	12.5
N21	1PBP1	3T1	1	1-1/2"	EMT	3	1/0	CU THWN	--	--	--	--	--	--	150	200	5	15	5
N22	3T1	3PNL1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	10	40	10
N23	3PNL1	3LNL1	1	2	EMT	3	3/0	CU THWN	1	3/0	CU THWN	1	6AWG	CU THWN	200	200	22	88	22
N24	3PNL1	3LNL2	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	149	596	149
N25	3PNL1	3LNL3	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	126	504	126
N26	3PNL1	3LNL4	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	104.5	418	104.5
N27	1PBP1	6T1	1	1-1/4"	EMT	3	2AWG	CU THWN	--	--	--	--	--	--	90	100	5	15	5
N28	1PBP1	6LNH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	20	80	20
N29	1PBP1	5LNH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	20	80	20
N30	1PBP1	4LNH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	20	80	20
N31	1PBP1	3LNH1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	20	80	20
N32	6T1	6LNL1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	150	100	20	80	20
N33	1PBP1	4T1	1	2-1/2"	EMT	3	350KCMIL	CU THWN	--	--	--	--	--	--	300	400	5	15	5
N34	4T1	4PNL1	2	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	2AWG	CU THWN	500	600	10	40	10
N35	4PNL1	4LNL1	1	2	EMT	3	3/0	CU THWN	1	3/0	CU THWN	1	6AWG	CU THWN	200	200	25	100	25
N36	4PNL1	4LNL2	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	143	572	143
N37	4PNL1	4LNL3	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	133.5	534	133.5
N38	4PNL1	4LNL4	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	92	368	92
N39	4PNL1	4LNL5	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	57	228	57
N40	4PNL1	4LNL6	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	73.5	294	73.5
N41	4PNL1	4LNL7	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	81	324	81
N42	4PNL1	4LNL8	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	66	264	66
N43	4PNL1	4LNL9	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	26.5	106	26.5
N44	4PNL1	4LNL10	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	34.5	138	34.5
N45	1PBP1	5T1	1	2-1/2"	EMT	3	350KCMIL	CU THWN	--	--	--	--	--	--	300	400	4	12	4
N46	5T1	5PNL1	2	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	2AWG	CU THWN	500	600	50	200	50
N47	5PNL1	5LNL1	1	2	EMT	3	3/0	CU THWN	1	3/0	CU THWN	1	6AWG	CU THWN	200	200	26	104	26
N48	5PNL1	5LNL2	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	153	612	153
N49	5PNL1	5LNL3	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	129	516	129
N50	5PNL1	5LNL4	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	89.5	358	89.5
N51	5PNL1	5LNL5	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	55.5	222	55.5
N52	5PNL1	5LNL6	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	108.5	434	108.5
N53	5PNL1	5LNL7	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	68	272	68
N54	5PNL1	5LNL8	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	27.5	110	27.5
N55	2PNH1	3PNH1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	297	1188	297
N56	2PNH1	6PNH1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	339	1356	339
N57	1USSHV1	FIRE PUMP	1	--	EMT	3	1/0	MI CABLE	--	--	MI CABLE	1	6AWG	MI CABLE	600	800	151	604	151
N58	1PNH1	STEAM UNIT	1	1-1/4"	EMT	3	4AWG	CU THWN	1	4	CU THWN	1	10AWG	CU THWN	60	100		0	0
O1	1LVSG1	1ATSO1	2	3	EMT	3	350KCMIL	CU THWN	1	350KCMIL	CU THWN	1	1/0	CU THWN	600	1600	30	120	30
O2	1ATSO1	1POH1	2	3	EMT	3	350KCMIL	CU THWN	1	350KCMIL	CU THWN	1	1/0	CU THWN	--	--	44	176	44
O3	1POH1	1PBP2	2	3	EMT	3	350KCMIL	CU THWN	1	350KCMIL	CU THWN	1	1/0	CU THWN	400	400	50	200	50
O4	1POH1	1POH2	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	92.5	370	92.5
O5	1POH1	1T5	1	1	EMT	3	4AWG	CU THWN	--	--	--	--	--	--	70	100	21	63	21
O6	1POH1	1T6	1	1-1/2"	EMT	3	1/0	CU THWN	--	--	--	--	--	--	150	200	12.5	37.5	12.5
O7	1T5	1LOL1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	125	200	6	24	6
O8	1T6	1LOL2	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	151	604	151
O9	1PBP2	6T4	1	3/4"	EMT	3	10AWG	CU THWN	--	--	--	--	--	--	--	--	10	30	10
O10	1PBP2	3T3	1	1	EMT	3	4AWG	CU THWN	--	--	--	--	--	--	70	100	5.5	16.5	5.5
O11	1PBP2	6POH1	1	2	EMT	3	3/0	CU THWN	1	3/0	CU THWN	1	6AWG	CU THWN	200		17.5	70	17.5
O12	3T3	3LOL1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	125	200	7.5	30	7.5
O13	6T4	6LOL1	1	1-1/4"	EMT	3	6AWG	CU THWN	1	6AWG	CU THWN	1	6AWG	CU THWN	60	60	5	20	5
O14	1PBP2	5T3	1	1-1/2"	EMT	3	1/0	CU THWN	--	--	--	--	--	--	150	200	3.5	10.5	3.5
O15	5T3	5POL1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	5	20	5
O16	1PBP2	4T3	1	1-1/2"	EMT	3	1/0	CU THWN	--	--	--	--	--	--	150	200	3.5	10.5	3.5
O17	4T3	4POL1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	5	20	5
O18	4POL1	4LOL1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	44.5	178	44.5
O19	4POL1	4LOL2	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	81	324	81
O20	5POL1	5LOL1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	28	112	28
O21	5POL1	5LOL2	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	100	100	83.5	334	83.5
S1	1LVSG1	1ATSS2	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	1600	19.5	78	19.5
S2	1LVSG1	1ATSS1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	1600	19.5	78	19.5
S3	1ATSS2	6PSH1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	237.5	950	237.5
S4	1ATSS1	1PSH1	1	2-1/2"	EMT	3	250KCMIL	CU THWN	1	250KCMIL	CU THWN	1	4AWG	CU THWN	250	400	221.5	886	221.5
S5	6PSH1	ELEV#1	1	1-1/4"	EMT	3	2AWG	CU THWN	--	--	--	1	8AWG	CU THWN	80	250	32.5	97.5	32.5
S6	6PSH1	ELEV#2	1	1-1/4"	EMT	3	2AWG	CU THWN	--	--	--	1	8AWG	CU THWN	80	250	35.5	106.5	35.5
S7	6PSH1	ELEV#3	1	1-1/4"	EMT	3	2AWG	CU THWN	--	--	--	1	8AWG	CU THWN	80	250	37.5	112.5	37.5
S8	1PSH1	2T3	1	3/4"	EMT	3	10AWG	CU THWN	1	10	CU THWN	1	8AWG	CU THWN	30	100	164.5	658	164.5
S9	1PSH1	3T2	1	3/4"	EMT	3	10AWG	CU THWN	1	10	CU THWN	1	8AWG	CU THWN	30	100	179.5	718	179.5
S10	1PSH1	4T2	1	3/4"	EMT	3	10AWG	CU THWN	1	10	CU THWN	1	8AWG	CU THWN	30	100	195.5	782	195.5
S11	1PSH1	5T2	1	3/4"	EMT	3	10AWG	CU THWN	1	10	CU THWN	1	8AWG	CU THWN	30	100	201	804	201
S12	1PSH1	6T3	1	3/4"	EMT	3	10AWG	CU THWN	1	10	CU THWN	1	8AWG	CU THWN	30	100	229.5	918	229.5
S13	1PSH1	FREIGHT ELEV	1	1-1/4"	EMT	3	2AWG	CU THWN	--	--	--	1	8AWG	CU THWN	90	100		0	0
S14	1PSH1	1T4	1	1	EMT	3	4AWG	CU THWN	--	--	--	--	--	--	70	100	11	33	11
S15	2T3	2LSL1	1	1-1/4"	EMT	3	6AWG	CU THWN	1	6AWG	CU THWN	1	6AWG	CU THWN	60	60	6	24	6
S16	3T2	3LSL1	1	1-1/4"	EMT	3	6AWG	CU THWN	1	6AWG	CU THWN	1	6AWG	CU THWN	60	60	5	20	5
S17	4T2	4LSL1	1	1-1/4"	EMT	3	6AWG	CU THWN	1	6AWG	CU THWN	1	6AWG	CU THWN	60	60	5	20	5
S18	5T2	5LSL1	1	1-1/4"	EMT	3	6AWG	CU THWN	1	6AWG	CU THWN	1	6AWG	CU THWN	60	60	6	24	6
S19	6T3	6LSL1	1	1-1/4"	EMT	3	6AWG	CU THWN	1	6AWG	CU THWN	1	6AWG	CU THWN	60	60	6	24	6
S20	1T4	1LSL1	1	1-1/2"	EMT	3	1/0	CU THWN	1	1/0	CU THWN	1	8AWG	CU THWN	125	200	5.5	22	5.5

V. ELECTRICAL DEPTH

E) ALUMINUM FEEDERS VS. COPPER FEEDERS

COPPER FEEDER ESTIMATE

COPPER FEEDER ESTIMATE

WIRE (THHN/THWN)

	UNIT	L.F.	C.L.F.	MATERIAL COST/ C.L.F.	MATERIAL TOTAL COST	LABOR COST/ C.L.F.	LABOR TOTAL COST	TOTAL LABOR & MATERIAL
10 AWG	C.L.F.	5026	50.26	25	$1,256.50	37.5	$1,884.75	$3,141.25
8 AWG		3588	35.88	43.5	$1,560.78	47	$1,686.36	$3,247.14
6 AWG	C.L.F.	860	8.6	67.5	$580.50	58	$498.80	$1,079.30
4 AWG	C.L.F.	1025	10.25	106	$1,086.50	71	$727.75	$1,814.25
2 AWG	C.L.F.	565.5	5.655	168	$950.04	83.5	$472.19	$1,422.23
1/0	C.L.F.	14211	142.11	259	$36,806.49	114	$16,200.54	$53,007.03
3/0	C.L.F.	1440	14.4	410	$5,904.00	150	$2,160.00	$8,064.00
250 KCMIL	C.L.F.	3708	37.08	610	$22,618.80	188	$6,971.04	$29,589.84
300 KCMIL		4956	49.56	725	$35,931.00	198	$9,812.88	$45,743.88
350 KCMIL	C.L.F.	7615	76.15	850	$64,727.50	209	$15,915.35	$80,642.85
400 KCMIL	C.L.F.	0	0	970	$0.00	221	$0.00	$0.00
500 KCMIL	C.L.F.	402	4.02	1175	$4,723.50	235	$944.70	$5,668.20
600 KCMIL		684	6.84	1400	$9,576.00	289	$1,976.76	$11,552.76
					TOTAL LABOR & MATERIAL			$244,972.73

CONDUIT (EMT)

	UNIT	L.F.		MATERIAL COST/L.F.	MATERIAL TOTAL COST	LABOR COST/ L.F.	LABOR TOTAL COST	TOTAL LABOR & MATERIAL
3/4"	C.L.F.	1352		0.86	$1,162.72	1.49	$2,014.48	$3,177.20
1"	C.L.F.	37.5		1.44	$54.00	1.82	$68.25	$122.25
1-1/4"	C.L.F.	168		2.45	$411.60	2.17	$364.56	$776.16
1-1/2"	C.L.F.	2893		3.18	$9,199.74	2.46	$7,116.78	$16,316.52
2"	C.L.F.	90.5		4.05	$366.53	2.89	$261.55	$628.07
2-1/2"	C.L.F.	936		9.5	$8,892.00	4.09	$3,828.24	$12,720.24
3"	C.L.F.	3236.5		10.9	$35,277.85	5.1	$16,506.15	$51,784.00
3-1/2"	C.L.F.	0		13.65	$0.00	5.6	$0.00	$0.00
4"	C.L.F.	100.5		14.25	$1,432.13	6.6	$663.30	$2,095.43
					TOTAL LABOR & MATERIAL			$87,619.87

COPPER FEEDER ESTIMATE	$332,592.60

ALUMINUM FEEDER SCHEDULE

TAG	FROM	TO	NO. OF SETS	CONDUIT (PER SET) SIZE	TYPE	CONDUCTORS (PER SET) PHASE CONDUCTORS No.	SIZE	TYPE	NEUTRAL CONDUCTORS No.	SIZE	TYPE	GROUND CONDUCTORS No.	SIZE	TYPE	SIZE OF OVERCURRENT PROTECTION	FRAME OR SWITCH SIZE	LENGTH OF RUN	TOTAL CONDUCTOR	GROUND LENGTH
E1	EGS-1	1SWBDG1	3	4"	PVC	3	600KCMIL	AL THWN	1	600KCMIL	AL THWN	1	3/0	AL THWN	--	--			0
E2	1SWBDG1	LOAD BANK	4	4"	PVC	3	500KCMIL	AL THWN	1	500KCMIL	AL THWN	?	1/0	AL THWN	1200	1600		0	0
E3	1SWBDG1	1LVSG1	3	4"	PVC	3	600KCMIL	AL THWN	1	600KCMIL	AL THWN	1	3/0	AL THWN	1000	1600	171	684	171
E4	1SWBDG1	FIRE PUMP	1	2"	PVC	3	3/0	AL THWN	--	--	--	1	4AWG	AL THWN	150	400	168	504	168
E5	1LVSG1	1ASTE1	1	3"	PVC	3	350KCMIL	AL THWN	1	350KCMIL	AL THWN	1	1/0	AL THWN	250	1600	15	15	15
E6	1ASTE1	1PEH1	1	3-1/2"	PVC	3	400KCMIL	AL THWN	1	400KCMIL	AL THWN	1	1/0	AL THWN	--	--	24	24	24
E7	1PEH1	2T2	1	3/4"	EMT	3	10AWG	AL THWN	--	--	--	--	--	--	30	30	156.5	469.5	156.5
E8	1PEH1	1T3	1	1"	EMT	3	3AWG	AL THWN	--	--	--	--	--	--	70	100	15	45	15
E9	1PEH1	6T2	1	3/4"	EMT	3	6AWG	AL THWN	--	--	--	--	--	--	30	30	215.5	646.5	215.5
E10	1PEH1	1LEH1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	9	36	9
E11	1PEH1	2LEH1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	162.5	650	162.5
E12	1PEH1	4LEH1	1	2"	EMT	3	3/0	AL THWN	1	3/0	AL THWN	1	4AWG	AL THWN	150	200	197.5	790	197.5
E13	2T2	2LEL1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	60	5.5	22	5.5
E14	1T3	1LEL1	1	2"	PVC	3	2/0	AL THWN	1	2/0	AL THWN	1	4AWG	AL THWN	125	200	68	272	68
E15	6T2	6LEL1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	60		0	0
E16	2LEH1	3LEH1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	--	--	16	64	16
E17	4LEH1	5LEH1	1	2"	EMT	3	3/0	AL THWN	1	3/0	AL THWN	1	4AWG	AL THWN	--	--	4.5	18	4.5
E18	5LEH1	6LEH1	1	2"	EMT	3	3/0	AL THWN	1	3/0	AL THWN	1	4AWG	AL THWN	--	--	22	88	22
N1	1USSHV1	1PBP1	4	4"	PVC	3	500KCMIL	AL THWN	1	500KCMIL	AL THWN	1	1/0	AL THWN	1200	1200	1078	4312	1078
N2	1USSHV1	1PNH1	2	4"	PVC	3	500KCMIL	AL THWN	1	500KCMIL	AL THWN	1	1/0	AL THWN	600	600	89	356	89
N3	1USSHV1	2PNH1	2	4"	EMT	3	500KCMIL	AL THWN	1	500KCMIL	AL THWN	1	1/0	AL THWN	600	600	305	1220	305
N4	1USSHV1	1PNH2	3	3"	EMT	3	400KCMIL	AL THWN	1	400KCMIL	AL THWN	1	1/0	AL THWN	800	800	378	1512	378
N5	1USSHV1	1PNH3	3	3"	EMT	3	400KCMIL	AL THWN	1	400KCMIL	AL THWN	1	1/0	AL THWN	800	800	435	1740	435
N6	1USSHV1	1PNH4	3	3"	EMT	3	400KCMIL	AL THWN	1	400KCMIL	AL THWN	1	1/0	AL THWN	800	800	426	1704	426
N7	1USSHV1	FUTURE	2	2-1/2"	EMT	3	250KCMIL	AL THWN	1	250KCMIL	AL THWN	1	2AWG	AL THWN	400	400		0	0
N8	1USSHV1	CHILLER	1	4"	EMT	3	600 KCMIL	AL THWN	1	600 KCMIL	AL THWN	1	3/0	AL THWN	350	400	100.5	402	100.5
N9	1USSHV1	1ATSE1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	48.5	194	48.5
N10	1USSHV1	1ATSS1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	47	188	47
N11	1USSHV1	1ATSS2	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	51	204	51
N12	1USSHV1	1ATSO1	2	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	600	600	104	416	104
N13	1PNH1	1T2	1	2"	EMT	3	300KCMIL	AL THWN	--	--	--	--	--	--	225	225	10.5	31.5	10.5
N14	1PNH1	1T1	1	1"	EMT	3	2AWG	AL THWN	--	--	--	--	--	--	90	100	14	42	14
N15	1PNH1	2T1	1	1-1/2"	EMT	3	3/0	AL THWN	--	--	--	--	--	--	150	200	59.5	178.5	59.5
N16	1PNH1	2LNH1	1	2"	EMT	3	3/0	AL THWN	1	3/0	AL THWN	1	4AWG	AL THWN	150	200	72.5	290	72.5
N17	1PNH1	1LNH1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	14.5	58	14.5
N18	1T2	1LNL2	1	2"	EMT	3	3/0	AL THWN	1	3/0	AL THWN	1	4AWG	AL THWN	150	200	66	264	66
N19	1T1	1LNL1	1	2"	EMT	3	3/0	AL THWN	1	3/0	AL THWN	1	4AWG	AL THWN	150	200	10.5	42	10.5
N20	2T1	2LNL1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	12.5	50	12.5
N21	1PBP1	3T1	1	1-1/2"	EMT	3	3/0	AL THWN	--	--	--	--	--	--	150	200	5	15	5
N22	3T1	3PNL1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	10	40	10
N23	3PNL1	3LNL1	1	2-1/2"	EMT	3	250KCMIL	AL THWN	1	250KCMIL	AL THWN	1	2AWG	AL THWN	200	200	22	88	22
N24	3PNL1	3LNL2	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	149	596	149
N25	3PNL1	3LNL3	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	126	504	126
N26	3PNL1	3LNL4	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	104.5	418	104.5
N27	1PBP1	6T1	1	1-1/2"	EMT	3	2AWG	AL THWN	--	--	--	--	--	--	90	100	5	15	5
N28	1PBP1	6LNH1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	20	80	20
N29	1PBP1	5LNH1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	20	80	20
N30	1PBP1	4LNH1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	20	80	20
N31	1PBP1	3LNH1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	20	80	20
N32	6T1	6LNL1	1	2"	EMT	3	3/0	AL THWN	1	3/0	AL THWN	1	4AWG	AL THWN	150	100	20	80	20
N33	1PBP1	4T1	1	2-1/2"	EMT	3	500KCMIL	AL THWN	--	--	--	--	--	--	300	400	5	15	5
N34	4T1	4PNL1	2	3"	EMT	3	350KCMIL	AL THWN	1	350KCMIL	AL THWN	1	1/0	AL THWN	500	600	10	40	10
N35	4PNL1	4LNL1	1	2-1/2"	EMT	3	250KCMIL	AL THWN	1	250KCMIL	AL THWN	1	2AWG	AL THWN	200	200	25	100	25
N36	4PNL1	4LNL2	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	143	572	143
N37	4PNL1	4LNL3	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	133.5	534	133.5
N38	4PNL1	4LNL4	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	92	368	92
N39	4PNL1	4LNL5	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	57	228	57
N40	4PNL1	4LNL6	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	73.5	294	73.5
N41	4PNL1	4LNL7	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	81	324	81
N42	4PNL1	4LNL8	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	66	264	66
N43	4PNL1	4LNL9	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	26.5	106	26.5
N44	4PNL1	4LNL10	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	34.5	138	34.5
N45	1PBP1	5T1	1	4"	EMT	3	500KCMIL	AL THWN	--	--	--	--	--	--	300	400	4	12	4
N46	5T1	5PNL1	2	3"	EMT	3	350KCMIL	AL THWN	1	350KCMIL	AL THWN	1	1/0	AL THWN	500	600	50	200	50
N47	5PNL1	5LNL1	1	2-1/2"	EMT	3	250KCMIL	AL THWN	1	250KCMIL	AL THWN	1	2AWG	AL THWN	200	200	26	104	26
N48	5PNL1	5LNL2	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	153	612	153
N49	5PNL1	5LNL3	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	129	516	129
N50	5PNL1	5LNL4	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	89.5	358	89.5
N51	5PNL1	5LNL5	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	55.5	222	55.5
N52	5PNL1	5LNL6	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	108.5	434	108.5
N53	5PNL1	5LNL7	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	68	272	68
N54	5PNL1	5LNL8	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	27.5	110	27.5
N55	2PNH1	3PNH1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	297	1188	297
N56	2PNH1	6PNH1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	339	1356	339
N57	1USSHV1	FIRE	1	--	EMT	3	1/0	MI CABLE	--	--	MI CABLE	1	6AWG	MI CABLE	600	800	151	151	151
N58	1PNH1	STEAM	1	1-1/2"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	100		0	0
O1	1LVSG1	1ATSO1	2	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	600	1600	30	120	30
O2	1ATSO1	1POH1	2	4"	EMT	3	500KCMIL	AL THWN	1	500KCMIL	AL THWN	1	1/0	AL THWN	--	--	44	176	44
O3	1POH1	1PBP2	2	2-1/2"	EMT	3	250KCMIL	AL THWN	1	250KCMIL	AL THWN	1	2AWG	AL THWN	400	400	50	200	50
O4	1POH1	1POH2	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	92.5	370	92.5
O5	1POH1	1T5	1	1"	EMT	3	3AWG	AL THWN	--	--	--	--	--	--	70	100	21	63	21
O6	1POH1	1T6	1	1-1/2"	EMT	3	3/0	AL THWN	--	--	--	--	--	--	150	200	12.5	37.5	12.5
O7	1T5	1LOL1	1	2"	EMT	3	2/0	AL THWN	1	2/0	AL THWN	1	4AWG	AL THWN	125	200	6	24	6
O8	1T6	1LOL2	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	151	604	151
O9	1PBP2	6T4	1	3/4	EMT	3	8AWG	AL THWN	--	--	--	--	--	--	--	--	10	30	10
O10	1PBP2	3T3	1	1"	EMT	3	3AWG	AL THWN	--	--	--	--	--	--	70	100	5.5	16.5	5.5
O11	1PBP2	6POH1	1	2-1/2"	EMT	3	250KCMIL	AL THWN	1	250KCMIL	AL THWN	1	2AWG	AL THWN	200		17.5	70	17.5
O12	3T3	3LOL1	1	2"	EMT	3	2/0	AL THWN	1	2/0	AL THWN	1	4AWG	AL THWN	125	200	7.5	30	7.5
O13	6T4	6LOL1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	60	5	20	5
O14	1PBP2	5T3	1	1-1/2"	EMT	3	3/0	AL THWN	--	--	--	--	--	--	150	200	3.5	10.5	3.5
O15	5T3	5POL1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	5	20	5
O16	1PBP2	4T3	1	1-1/2"	EMT	3	3/0	AL THWN	--	--	--	--	--	--	150	200	3.5	10.5	3.5
O17	4T3	4POL1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	5	20	5
O18	4POL1	4LOL1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	44.5	178	44.5
O19	4POL1	4LOL2	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	81	324	81
O20	5POL1	5LOL1	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	28	112	28
O21	5POL1	5LOL2	1	1-1/2"	EMT	3	1AWG	AL THWN	1	1AWG	AL THWN	1	6AWG	AL THWN	100	100	83.5	334	83.5
S1	1LVSG1	1ATSS2	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	1600	19.5	78	19.5
S2	1LVSG1	1ATSS1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	1600	19.5	78	19.5
S3	1ATSS2	6PSH1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	237.5	950	237.5
S4	1ATSS1	1PSH1	1	3"	EMT	3	350 KCMIL	AL THWN	1	350 KCMIL	AL THWN	1	1/0	AL THWN	250	400	221.5	886	221.5
S5	6PSH1	ELEV#1	1	1-1/4"	EMT	3	2AWG	AL THWN	--	--	--	1	6AWG	AL THWN	80	250	32.5	97.5	32.5
S6	6PSH1	ELEV#2	1	1-1/4"	EMT	3	2AWG	AL THWN	--	--	--	1	6AWG	AL THWN	80	250	35.5	106.5	35.5
S7	6PSH1	ELEV#3	1	1-1/4"	EMT	3	2AWG	AL THWN	--	--	--	1	6AWG	AL THWN	80	250	37.5	112.5	37.5
S8	1PSH1	2T3	1	3/4"	EMT	3	10AWG	AL THWN	1	10AWG	AL THWN	1	6AWG	AL THWN	30	100	164.5	658	164.5
S9	1PSH1	3T2	1	3/4"	EMT	3	10AWG	AL THWN	1	10AWG	AL THWN	1	6AWG	AL THWN	30	100	179.5	718	179.5
S10	1PSH1	4T2	1	3/4"	EMT	3	10AWG	AL THWN	1	10AWG	AL THWN	1	6AWG	AL THWN	30	100	195.5	782	195.5
S11	1PSH1	5T2	1	3/4"	EMT	3	10AWG	AL THWN	1	10AWG	AL THWN	1	6AWG	AL THWN	30	100	201	804	201
S12	1PSH1	6T3	1	3/4"	EMT	3	10AWG	AL THWN	1	10AWG	AL THWN	1	6AWG	AL THWN	30	100	229.5	918	229.5
S13	1PSH1	FREIGHT	1	1-1/4"	EMT	3	2AWG	AL THWN	--	--	--	1	6AWG	AL THWN	90	100		0	0
S14	1PSH1	1T4	1	1-1/4"	EMT	3	3AWG	AL THWN	--	--	--	--	--	--	70	100	11	33	11
S15	2T3	2LSL1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	60	6	24	6
S16	3T2	3LSL1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	60	5	20	5
S17	4T2	4LSL1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	60	5	20	5
S18	5T2	5LSL1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	60	6	24	6
S19	6T3	6LSL1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	6AWG	AL THWN	60	60	6	24	6
S20	1T4	1LSL1	1	1-1/4"	EMT	3	2/0	AL THWN	1	2/0	AL THWN	1	4AWG	AL THWN	125	200	5.5	22	5.5

V. ELECTRICAL DEPTH

E) ALUMINUM FEEDERS VS. COPPER FEEDERS

ALUMINUM FEEDER ESTIMATE

ALUMINUM FEEDER ESTIMATE

WIRE (THHN/THWN) ***COPPER USED UNTIL #6AWG FOR ESTIMATE***

	UNIT	L.F.	C.L.F.	MATERIAL COST/ C.L.F.	MATERIAL TOTAL COST	LABOR COST/ C.L.F.	LABOR TOTAL COST	TOTAL LABOR & MATERIAL
10 AWG	C.L.F.	4349.5	43.495	25	$1,087.38	37.5	$1,631.06	$2,718.44
8 AWG	C.L.F.	30	0.3	43.5	$13.05	47	$14.10	$27.15
6 AWG	C.L.F.	4240.5	42.405	31.5	$1,335.76	47	$1,993.04	$3,328.79
4 AWG	C.L.F.	782	7.82	39.5	$308.89	58	$453.56	$762.45
3 AWG	C.L.F.	157.5	1.575	53.5	$84.26	71	$111.83	$196.09
2 AWG	C.L.F.	197.5	1.975	53.5	$105.66	71	$140.23	$245.89
1 AWG	C.L.F.	9258	92.58	78.5	$7,267.53	83.5	$7,730.43	$14,997.96
1/0	C.L.F.	3665	36.65	94	$3,445.10	94	$3,445.10	$6,890.20
2/0	C.L.F.	318	3.18	112	$356.16	104	$330.72	$686.88
3/0	C.L.F.	2571.5	25.715	138	$3,548.67	114	$2,931.51	$6,480.18
250 KCMIL	C.L.F.	492	4.92	188	$924.96	130	$639.60	$1,564.56
300 KCMIL	C.L.F.	0	0	259	$0.00	139	$0.00	$0.00
350 KCMIL	C.L.F.	4103	41.03	264	$10,831.92	150	$6,154.50	$16,986.42
400 KCMIL	C.L.F.	4980	49.8	310	$15,438.00	163	$8,117.40	$23,555.40
500 KCMIL	C.L.F.	6091	60.91	340	$20,709.40	188	$11,451.08	$32,160.48
600 KCMIL	C.L.F.	1086	10.86	430	$4,669.80	198	$2,150.28	$6,820.08
					TOTAL LABOR & MATERIAL			$117,420.97

CONDUIT (EMT)

	UNIT	L.F.		MATERIAL COST/L.F.	MATERIAL TOTAL COST	LABOR COST/ L.F.	LABOR TOTAL COST	TOTAL LABOR & MATERIAL
3/4"	C.L.F.	1352		0.86	$1,162.72	1.49	$2,014.48	$3,177.20
1"	C.L.F.	50		1.44	$72.00	1.82	$91.00	$163.00
1-1/4"	C.L.F.	159		2.45	$389.55	2.17	$345.03	$734.58
1-1/2"	C.L.F.	2418		3.18	$7,689.24	2.46	$5,948.28	$13,637.52
2"	C.L.F.	485		4.05	$1,964.25	2.89	$1,401.65	$3,365.90
2-1/2"	C.L.F.	145.5		9.5	$1,382.25	4.09	$595.10	$1,977.35
3"	C.L.F.	2261		10.9	$24,644.90	5.1	$11,531.10	$36,176.00
3-1/2"	C.L.F.	0		13.65	$0.00	5.6	$0.00	$0.00
4"	C.L.F.	1620.5		14.25	$23,092.13	6.6	$10,695.30	$33,787.43
					TOTAL LABOR & MATERIAL			$93,018.97

ALUMINUM FEEDER ESTIMATE	$210,439.94

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

INTRODUCTION/ASSUMPTIONS

SKM Power Tools is a program that allows users to conduct short circuit studies, arc fault studies, and selective coordination studies of overcurrent protective devices. The actual electrical design of this building was incorporated into the model. None of the redesigned panels were used shown in the Electrical Depth section of the report. The lengths and sizes of feeder runs were already documented in the "Aluminum Feeders VS. Copper Feeders" section of the Electrical Depth. Advice was sought from Professor Kenneth Davidson and his colleague Scott McCall, P.E. for the program.

Products such as panelboards, switchboards, circuit breakers, switches, and other related components were chosen from the built in library provided by the program. This was done in order to obtain realistic data for each study. The conduit was assumed to be magnetic for all runs. Some branch panels were omitted due to the 100 bus limitation set forth by SKM's trial version. Only Cutler-Hammer products were used to ensure all the components were compatible. The only exception for this assumption occurs with the run which a hand calculation was conducted for a short circuit study. The information for components from the hand calculation was entered into SKM, so no manufacturers' products were selected. This was done in order to compare the SKM calculation to the hand one.

CONCLUSION

SKM Power Tools proved to be a valuable tool for conducting short circuit analysis studies. After comparing the hand calculation to the SKM short circuit analysis, the results proved to be very similar. Below is a chart comparing the results:

	SKM SHORT CIRCUIT ANALYSIS I_{SC}(AMPS)	SHORT CIRCUIT HAND CALCULATION ISC(AMPS)	% DIFFERENCE
SUBSTATION 1USSHV1	54283 A	50999	6.05%
SWITCHBOARD 1PNH1	45573 A	42437	6.90%
PANEL 1LNL1	1357 A	1820	25.40%

There is only a significant difference in available short current values very far downstream. However, this is not a problem at all considering the minimum AIC rating for a breaker is 10,000A for commercial applications. The SKM values tend to be higher at upstream points. However, the hand calculation values are higher after the step down transformer from 480Y/277V to 208Y/120V. A difference in the calculation of transformer impedance or using SKM's library for wire could be the only reasons for greater differences between values downstream.

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

CONCLUSION(CONT'D)

The arc flash study was difficult to perform with this software. The program would not display incident energy values for each panel. Coordination studies were also very complex with the program's settings. With all of the settings and a poor help index, making use of these two functions is rather difficult for first time users.

ARCH FAULT ANALYSIS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Bus Name	Protective	Bus	Bus	Bus	Prot Dev	Prot Dev	Trip/	Breaker	Ground	Equip	Gap	Arc	Working	Incident	Required	Label #	Cable
2		Device	kV	Bolted	Arcing	Bolted	Arcing	Delay	Opening		Type	(mm)	Flash	Distance	Energy	Protective FR		Length
3		Name		Fault	Fault	Fault	Fault	Time	Time				Boundary	(in)	(cal/cm2)	Clothing Category		From Trip
4				(kA)	(kA)	(kA)	(kA)	(sec.)	(sec.)				(in)					Device (ft)
5	1LNH1	PD-0029	0.48	37.95	20.49	37.95	20.49	0.01	0.000	No	PNL	25	16	18	0.94	Category 0	# 0001	14.50
6																		
7	1LNL1	PD-0150	0.208	0.44	0.44	0.44	0.44	2	0.000	Yes	PNL	25	11	18	0.45	Category 0 (*N11)	# 0003	
8																		
9	1LNL2	PD-0070	0.208	0.33	0.33	0.33	0.33	2	0.000	Yes	PNL	25	9.5	18	0.33	Category 0 (*N11)	# 0003	
10																		
11	1LVSG1	MaxTripTi	0.48			0.00	0.00	2	0.000	No	PNL	25	0	18	0	(*N2) (*N9)	# 0005	
12																		
13	1PBP1	PD-0016	0.48	33.58	15.69	33.58	15.69	0.09	0.000	No	PNL	25	50	18	6.3	Category 2 (*N3)	# 0006	269.50
14																		
15	1PEH1	PD-0006	0.48	31.19	17.33	31.19	17.33	0.011	0.000	No	PNL	25	14	18	0.83	Category 0	# 0055	72.50
16																		
17	1PNH1	PD-0015	0.48	45.57	23.96	45.57	23.96	0.035	0.000	No	PNL	25	37	18	3.9	Category 1	# 0008	44.50
18																		
19	1PNH2	PD-0011	0.48	38.79	17.74	38.79	17.74	0.047	0.000	No	PNL	25	36	18	3.8	Category 1 (*N3)	# 0011	126.00
20																		
21	1PNH3	PD-0010	0.48	37.05	17.06	37.05	17.06	0.05	0.000	No	PNL	25	37	18	3.8	Category 1 (*N3)	# 0011	145.00
22																		
23	1PNH4	PD-0009	0.48	37.31	17.17	37.31	17.17	0.05	0.000	No	PNL	25	37	18	3.8	Category 1 (*N3)	# 0011	142.00
24																		
25	1POH1	PD-0085	0.48	39.19	17.90	39.19	17.90	0.047	0.000	No	PNL	25	36	18	3.8	Category 1 (*N3)	# 0012	
26																		
27	1POH2	PD-0082	0.48	15.68	9.63	15.68	9.63	0.014	0.000	No	PNL	25	12	18	0.59	Category 0	# 0013	92.50
28																		
29	1POH3	PD-0081	0.48	36.13	19.65	36.13	19.65	0.01	0.000	No	PNL	25	15	18	0.89	Category 0	# 0012	25.00
30																		
31	1PSH1	PD-0117	0.48	12.09	7.71	12.09	7.71	0.1	0.000	No	PNL	25	33	18	3.2	Category 1	# 0055	
32																		
33	1SWBDG1	PD-0072	0.48					2	0.000	No	PNL	25	0	18	0	(*N9)	# 0014	
34																		
35	1USSHV1	PD-0003	0.48	54.28	25.77	0.80	0.38	0.083	0.000	No	SWG	32	74	24	6.3	Category 2		
36	1USSHV1	PD-0007	0.48	54.28	25.77	1.45	0.69	0.083	0.000	No	SWG	32	74	24	6.3	Category 2		
37	1USSHV1	PD-0008	0.48	54.28	25.77	52.04	24.70	0.15	0.000	No	SWG	32	110	24	11	Category 3	# 0015	
38																		
39	2LNH1	PD-0028	0.48	19.66	11.68	19.66	11.68	0.013	0.000	No	PNL	25	12	18	0.66	Category 0	# 0016	72.50
40																		
41	2LNL1	PD-0149	0.208	0.45	0.45	0.45	0.45	2	0.000	Yes	PNL	25	11	18	0.46	Category 0 (*N11)	# 0003	
42																		

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

ARCH FAULT ANALYSIS(CONT'D)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
43	2PNH1	PD-0012	0.48	31.86	15.00	31.86	15.00	0.09	0.000	No	PNL	25	48	18	6.0	Category 2 (*N3)	# 0018	152.50
44																		
45	3LNH1	PD-0016	0.48	27.06	15.35	27.06	15.35	0.09	0.000	No	PNL	25	49	18	6.2	Category 2	# 0050	289.50
46																		
47	3LNL1	PD-0122	0.208	0.44	0.44	0.44	0.44	2	0.000	Yes	PNL	25	11	18	0.45	Category 0 (*N11)	# 0020	26.00
48																		
49	3LNL2	PD-0068	0.208	0.41	0.41	0.41	0.41	2	0.000	Yes	PNL	25	11	18	0.42	Category 0 (*N11)	# 0021	149.00
50																		
51	3LNL3	PD-0059	0.208	0.42	0.42	0.42	0.42	0.231	0.000	Yes	PNL	25	3.7	18	0.05	Category 0 (*N11)	# 0021	126.00
52																		
53	3LNL4	PD-0067	0.208	0.42	0.42	0.42	0.42	0.227	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	104.50
54																		
55	3PNH1	PD-0021	0.48	9.86	6.48	9.86	6.48	0.019	0.000	No	PNL	25	11	18	0.50	Category 0	# 0024	297.00
56																		
57	3PNL1	PD-0122	0.208	0.45	0.45	0.45	0.45	2	0.000	Yes	PNL	25	11	18	0.45	Category 0 (*N11)	# 0025	
58																		
59	4LNH1	PD-0016	0.48	27.06	15.35	27.06	15.35	0.09	0.000	No	PNL	25	49	18	6.2	Category 2	# 0050	289.50
60																		
61	4LNL1	PD-0052	0.208	0.46	0.46	0.46	0.46	2	0.000	Yes	PNL	25	11	18	0.47	Category 0 (*N11)	# 0027	25.00
62																		
63	4LNL10	PD-0041	0.208	0.45	0.45	0.45	0.45	0.203	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	34.50
64																		
65	4LNL2	PD-0033	0.208	0.43	0.43	0.43	0.43	2	0.000	Yes	PNL	25	11	18	0.44	Category 0 (*N11)	# 0021	143.00
66																		
67	4LNL3	PD-0034	0.208	0.43	0.43	0.43	0.43	0.221	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	133.50
68																		
69	4LNL4	PD-0035	0.208	0.44	0.44	0.44	0.44	0.213	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	92.00
70																		
71	4LNL5	PD-0036	0.208	0.45	0.45	0.45	0.45	0.207	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	57.00
72																		
73	4LNL6	PD-0037	0.208	0.44	0.44	0.44	0.44	0.21	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	73.50
74																		
75	4LNL7	PD-0038	0.208	0.44	0.44	0.44	0.44	0.211	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	81.00
76																		
77	4LNL8	PD-0039	0.208	0.44	0.44	0.44	0.44	0.209	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	66.00
78																		
79	4LNL9	PD-0040	0.208	0.45	0.45	0.45	0.45	0.202	0.000	Yes	PNL	25	3.6	18	0.05	Category 0 (*N11)	# 0021	26.50
80																		
81	4PNL1	PD-0016	0.208	0.46	0.46	0.46	0.46	2	0.000	Yes	PNL	25	11	18	0.47	Category 0 (*N11)	# 0037	279.50
82																		
83	4POL1	PD-0092	0.208	0.46	0.46	0.46	0.46	2	0.000	Yes	PNL	25	11	18	0.47	Category 0 (*N11)	# 0038	
84																		

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

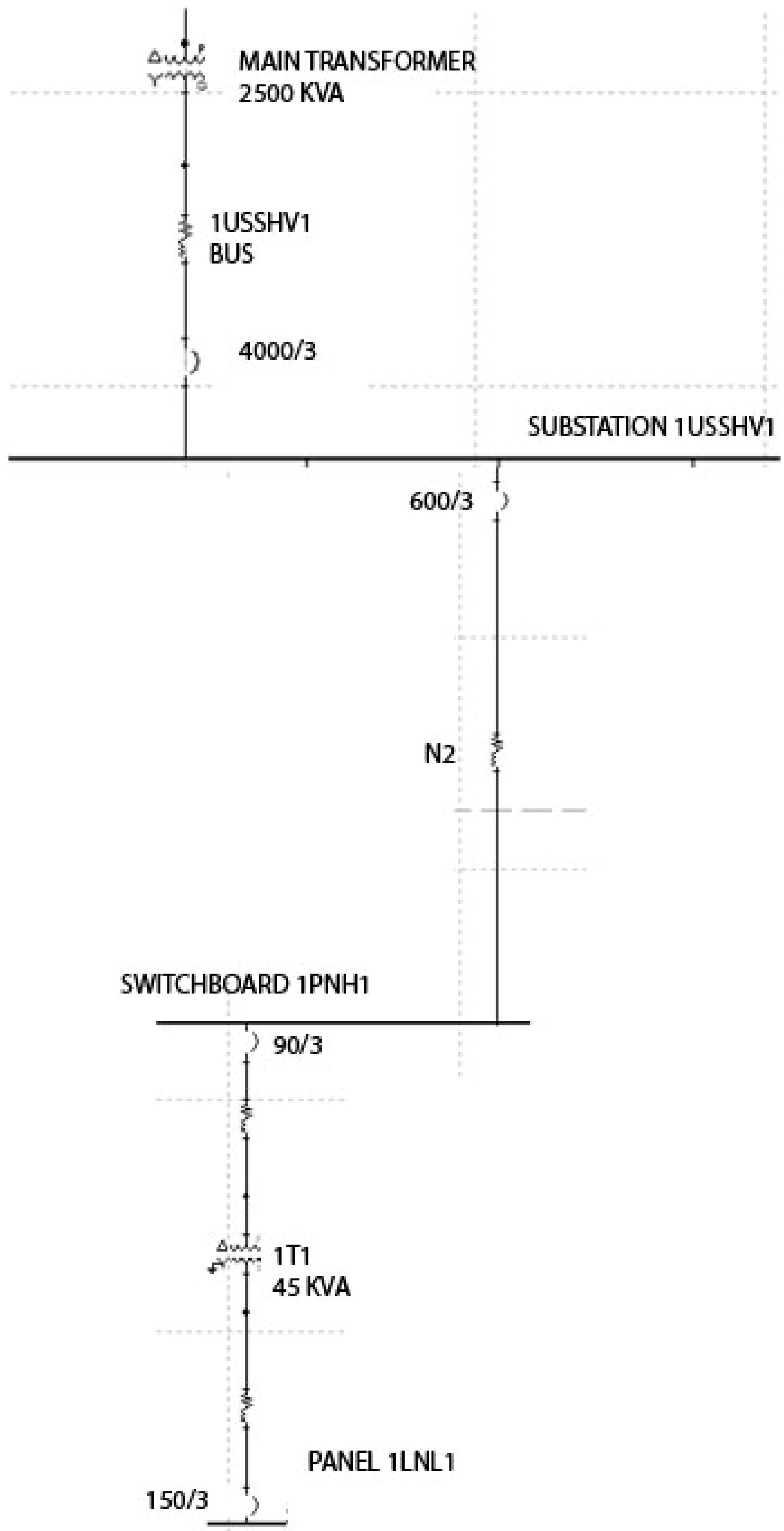
ARCH FAULT ANALYSIS(CONT'D)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
85	5LNH1	PD-0016	0.48	27.06	15.35	27.06	15.35	0.09	0.000	No	PNL	25	49	18	6.2	Category 2	# 0050	289.50
86																		
87	5LNL1	PD-0031	0.208	0.40	0.40	0.40	0.40	2	0.000	Yes	PNL	25	11	18	0.41	Category 0 (*N11)	# 0040	26.00
88																		
89	5LNL2	PD-0054	0.208	0.38	0.38	0.38	0.38	2	0.000	Yes	PNL	25	10	18	0.39	Category 0 (*N11)	# 0021	153.00
90																		
91	5LNL3	PD-0056	0.208	0.38	0.38	0.38	0.38	2	0.000	Yes	PNL	25	10	18	0.39	Category 0 (*N11)	# 0021	129.00
92																		
93	5LNL4	PD-0055	0.208	0.39	0.39	0.39	0.39	0.261	0.000	Yes	PNL	25	3.7	18	0.05	Category 0 (*N11)	# 0021	89.50
94																		
95	5LNL5	PD-0057	0.208	0.40	0.40	0.40	0.40	0.254	0.000	Yes	PNL	25	3.7	18	0.05	Category 0 (*N11)	# 0021	55.50
96																		
97	5LNL6	PD-0061	0.208	0.39	0.39	0.39	0.39	0.264	0.000	Yes	PNL	25	3.8	18	0.05	Category 0 (*N11)	# 0021	108.50
98																		
99	5LNL7	PD-0063	0.208	0.39	0.39	0.39	0.39	0.256	0.000	Yes	PNL	25	3.7	18	0.05	Category 0 (*N11)	# 0021	68.00
100																		
101	5LNL8	PD-0065	0.208	0.40	0.40	0.40	0.40	0.248	0.000	Yes	PNL	25	3.7	18	0.05	Category 0 (*N11)	# 0021	27.50
102																		
103	5PNL1	PD-0016	0.208	0.41	0.41	0.41	0.41	2	0.000	Yes	PNL	25	11	18	0.41	Category 0 (*N11)	# 0048	299.50
104																		
105	5POL1	PD-0096	0.208	0.46	0.46	0.46	0.46	2	0.000	Yes	PNL	25	11	18	0.47	Category 0 (*N11)	# 0049	
106																		
107	6LNH1	PD-0016	0.48	27.06	15.35	27.06	15.35	0.09	0.000	No	PNL	25	49	18	6.2	Category 2	# 0050	289.50
108																		
109	6LNL1	PD-0156	0.208	0.42	0.42	0.42	0.42	0.463	0.000	Yes	PNL	25	5.2	18	0.10	Category 0 (*N11)	# 0051	
110																		
111	6PNH1	PD-0023	0.48	8.95	5.96	8.95	5.96	0.02	0.000	No	PNL	25	10	18	0.48	Category 0	# 0052	339.00
112																		
113	6POH1	PD-0081	0.48	31.24	17.35	31.24	17.35	0.011	0.000	No	PNL	25	14	18	0.83	Category 0	# 0053	42.50
114																		
115	6PSH1	PD-0108	0.48	12.58	7.98	11.93	7.57	0.017	0.000	No	PNL	25	11	18	0.56	Category 0	# 0054	
116	6PSH1	PD-0110	0.48	12.58	7.98	0.28	0.18	0.083	0.000	No	PNL	25	14	18	0.75	Category 0		
117	6PSH1	PD-0116	0.48	12.58	7.98	0.28	0.18	0.083	0.000	No	PNL	25	14	18	0.75	Category 0		
118	6PSH1	PD-0118	0.48	12.58	7.98	0.28	0.18	0.083	0.000	No	PNL	25	14	18	0.75	Category 0		
119																		
120	Category 0: Nonmelting, Flammable Materials with Weight >= 4.5 oz/sq yd															(*N11) - Out of IEEE 1584 Range, Lee Equation Used.		
121	Category 1: Arc-rated FR Shirt & Pants															(*N2) < 80% Cleared Fault		
122	Category 2: Arc-rated FR Shirt & Pants															(*N3) - Arcing Current Low		

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

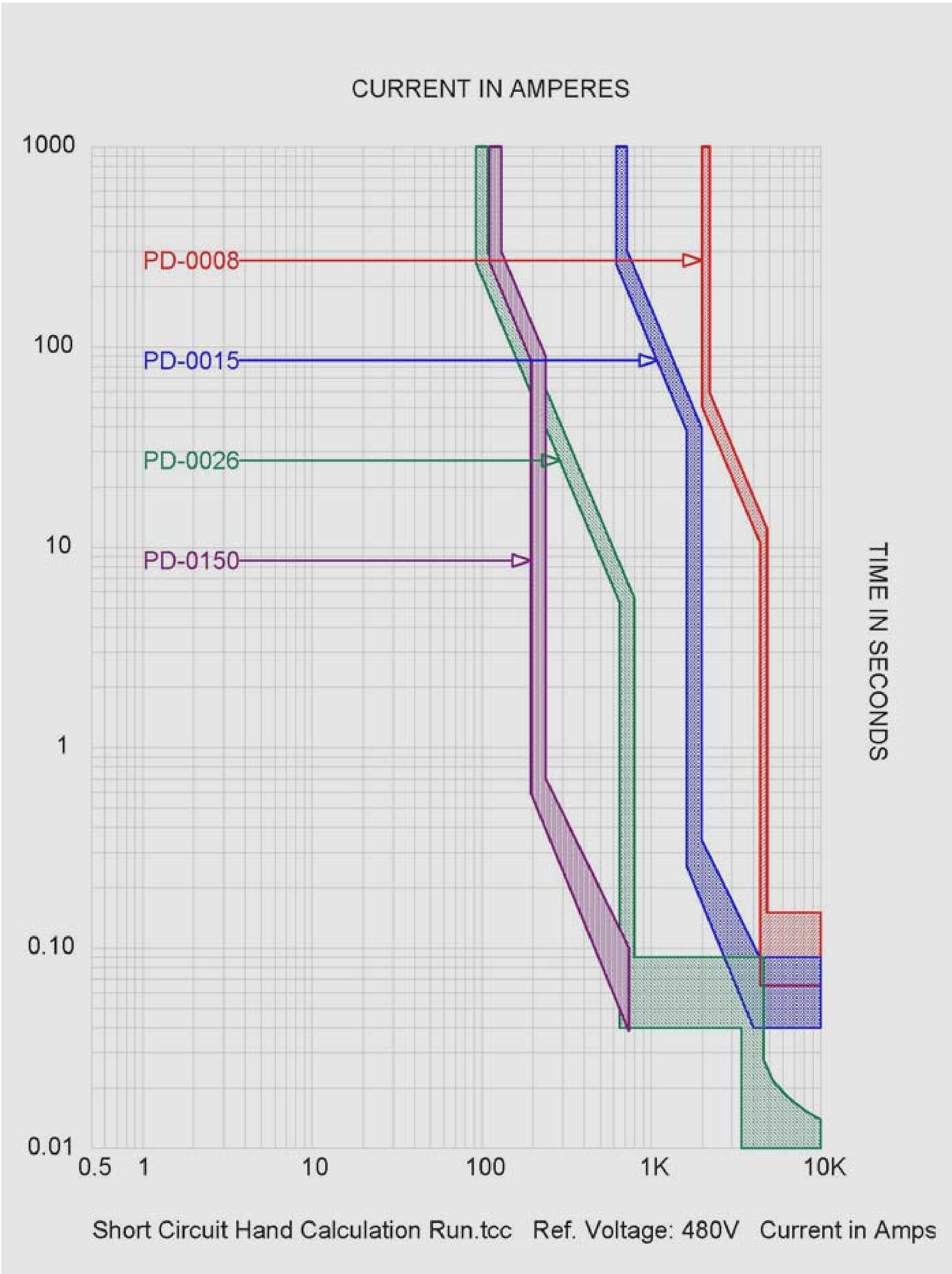
COORDINATION STUDY



V. ELECTRICAL DEPTH

F) SKM ANALYSIS

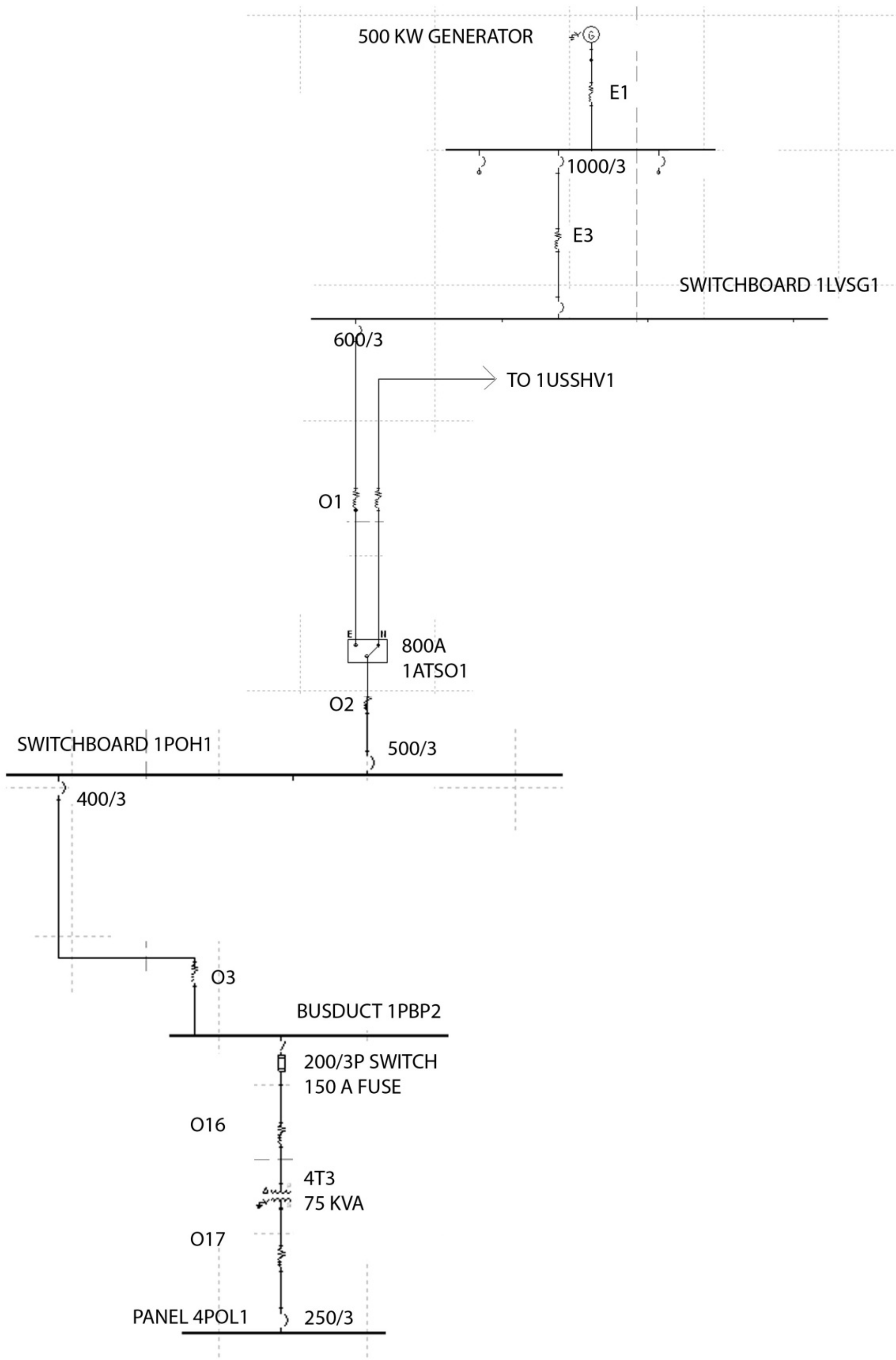
COORDINATION STUDY (CONT'D)



V. ELECTRICAL DEPTH

F) SKM ANALYSIS

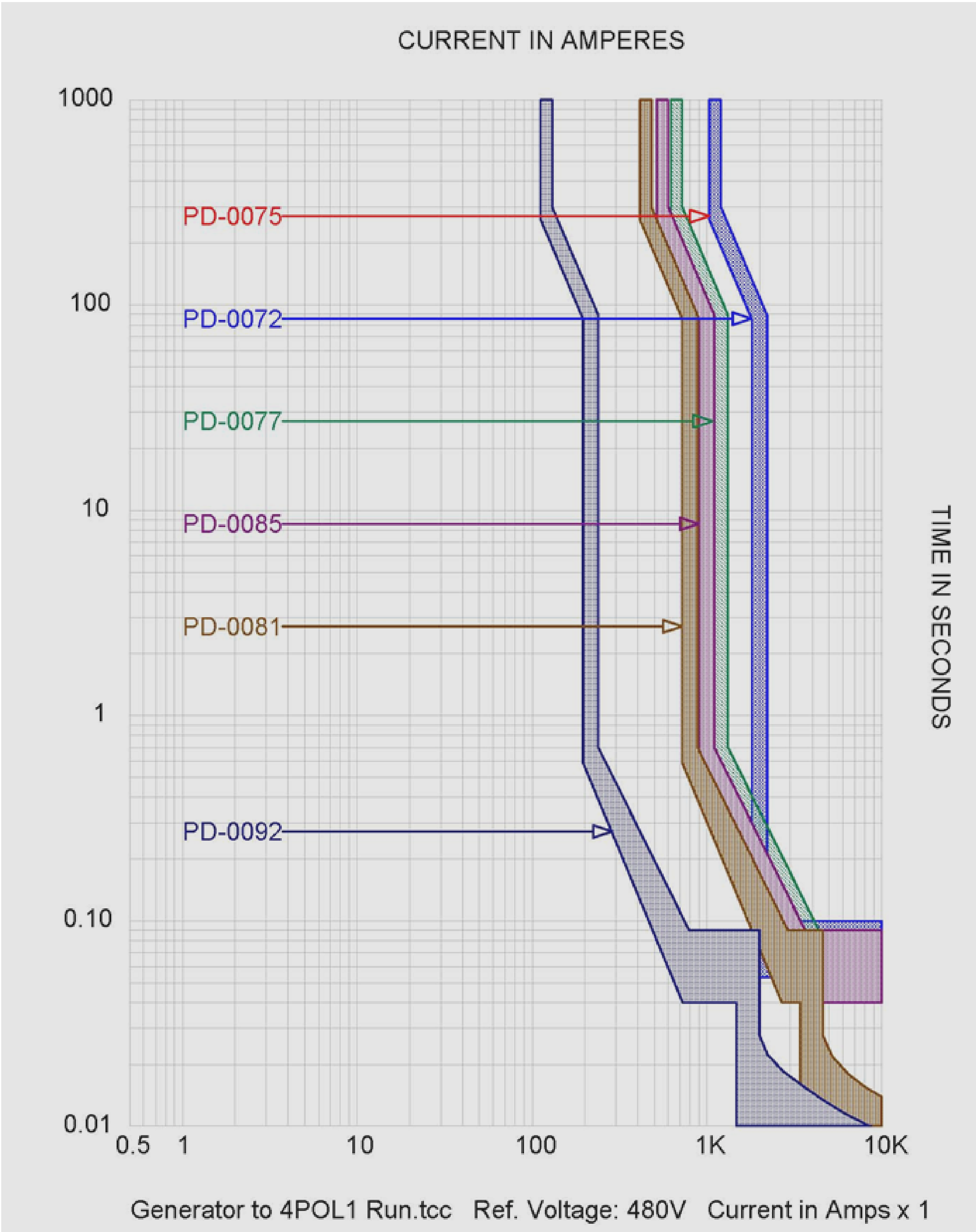
COORDINATION STUDY (CONT'D)



V. ELECTRICAL DEPTH

F) SKM ANALYSIS

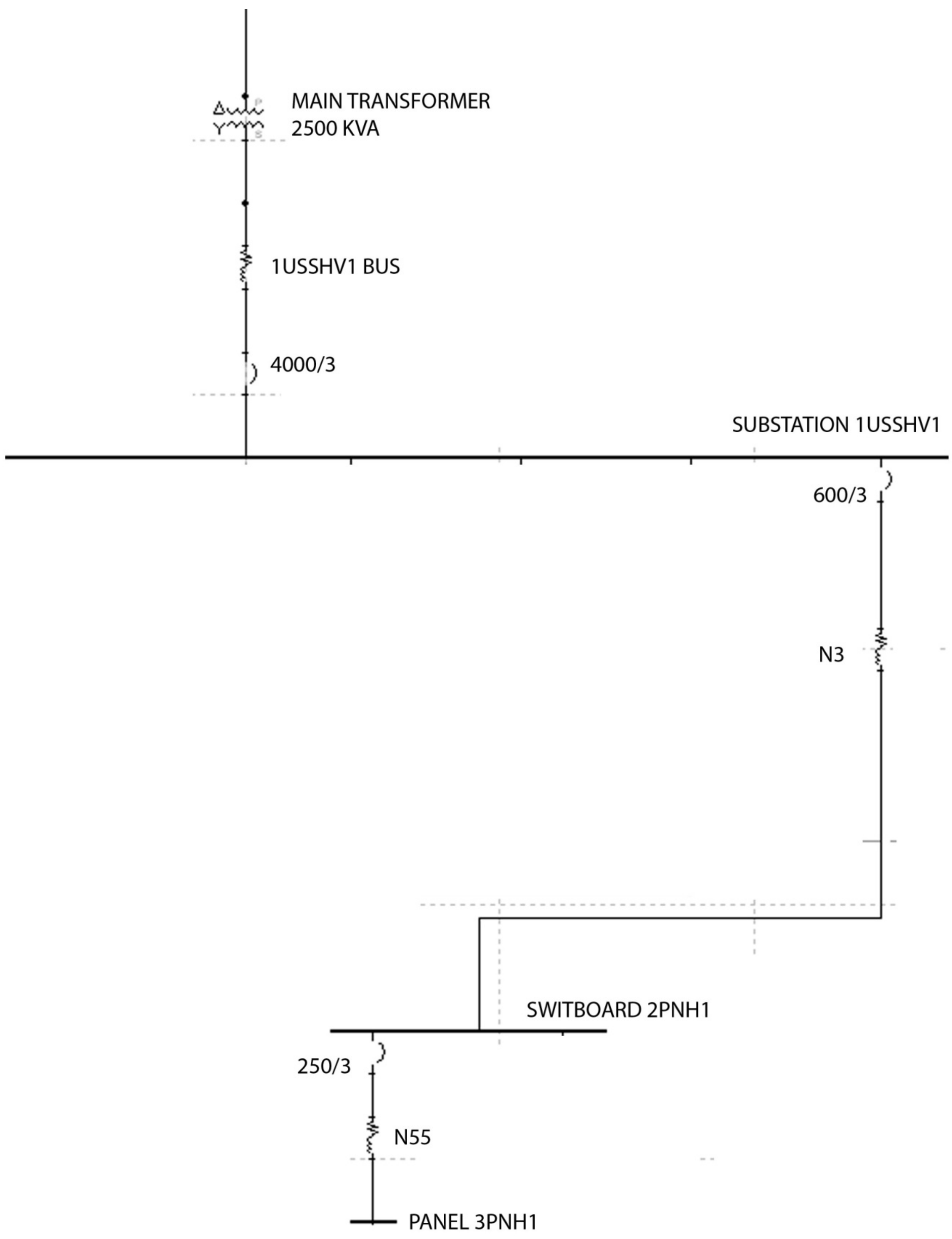
COORDINATION STUDY (CONT'D)



V. ELECTRICAL DEPTH

F) SKM ANALYSIS

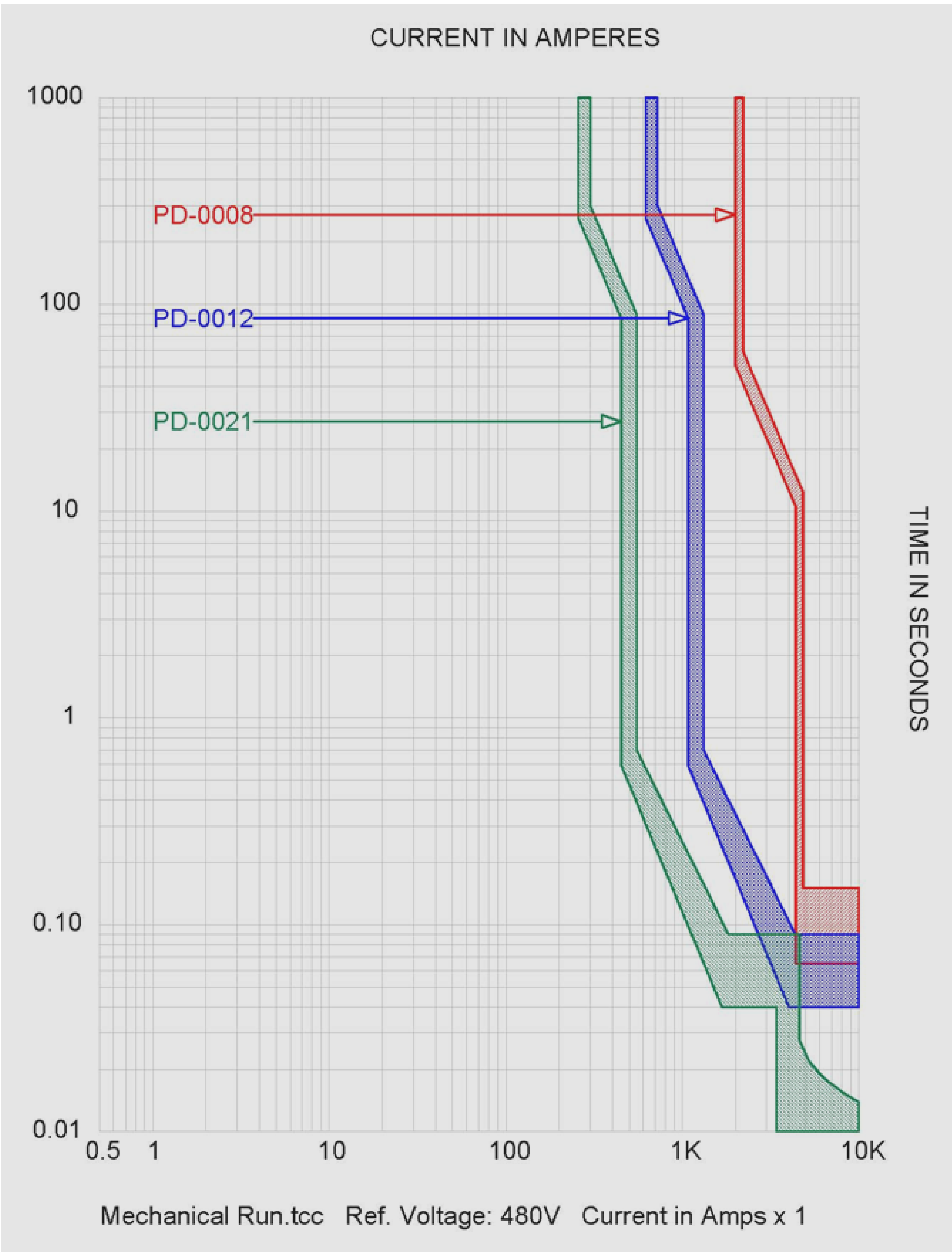
COORDINATION STUDY (CONT'D)



V. ELECTRICAL DEPTH

F) SKM ANALYSIS

COORDINATION STUDY (CONT'D)



V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS

Apr 04, 2009 21:10:37

ALL INFORMATION PRESENTED IS FOR REVIEW, APPROVAL
INTERPRETATION AND APPLICATION BY A REGISTERED ENGINEER ONLY
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SKM POWER*TOOLS FOR WINDOWS
SHORT CIRCUIT ANALYSIS REPORT

ALL PU VALUES ARE EXPRESSED ON A 100 MVA BASE

SWING GENERATORS

SOURCE NAME	VOLTAGE	ANGLE
UTIL-0002	1.00	0.00

************* P R E - F A U L T   V O L T A G E   P R O F I L E **************

BUS# NAME	BASE VOLTS	PU VOLTS	ANGLE (D)
1LNH1	480.00	0.9756	-30.
1LNL1	208.00	0.9756	-60.
1LNL2	208.00	0.9756	-60.
1LVSG1	480.00	0.0000	0.
1PBP1	480.00	0.9756	-30.
1PEH1	480.00	0.9756	-30.
1PNH1	480.00	0.9756	-30.
1PNH2	480.00	0.9756	-30.
1PNH3	480.00	0.9756	-30.
1PNH4	480.00	0.9756	-30.
1POH1	480.00	0.9756	-30.
1POH2	480.00	0.9756	-30.
1POH3	480.00	0.9756	-30.
1PSH1	480.00	0.9756	-30.
1SWBDG1	480.00	0.0000	0.
1USSHV1	480.00	0.9756	-30.
2LNH1	480.00	0.9756	-30.
2LNL1	208.00	0.9756	-60.
2PNH1	480.00	0.9756	-30.
3LNH1	480.00	0.9756	-30.
3LNL1	208.00	0.9756	-60.
3LNL2	208.00	0.9756	-60.
3LNL3	208.00	0.9756	-60.
3LNL4	208.00	0.9756	-60.
3PNH1	480.00	0.9756	-30.

3PNL1	208.00	0.9756	-60.

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

************* P R E - F A U L T   V O L T A G E   P R O F I L E **************

BUS# NAME	BASE VOLTS	PU VOLTS	ANGLE (D)
4LNH1	480.00	0.9756	-30.
4LNL1	208.00	0.9756	-60.
4LNL10	208.00	0.9756	-60.
4LNL2	208.00	0.9756	-60.
4LNL3	208.00	0.9756	-60.
4LNL4	208.00	0.9756	-60.
4LNL5	208.00	0.9756	-60.
4LNL6	208.00	0.9756	-60.
4LNL7	208.00	0.9756	-60.
4LNL8	208.00	0.9756	-60.
4LNL9	208.00	0.9756	-60.
4PNL1	208.00	0.9756	-60.
4POL1	208.00	0.9756	-60.
5LNH1	480.00	0.9756	-30.
5LNL1	208.00	0.9756	-60.
5LNL2	208.00	0.9756	-60.
5LNL3	208.00	0.9756	-60.
5LNL4	208.00	0.9756	-60.
5LNL5	208.00	0.9756	-60.
5LNL6	208.00	0.9756	-60.
5LNL7	208.00	0.9756	-60.
5LNL8	208.00	0.9756	-60.
5PNL1	208.00	0.9756	-60.
5POL1	208.00	0.9756	-60.
6LNH1	480.00	0.9756	-30.
6LNL1	208.00	0.9756	-60.
6PNH1	480.00	0.9756	-30.
6POH1	480.00	0.9756	-30.
6PSH1	480.00	0.9756	-30.
BUS-0012	480.00	0.9756	-30.
BUS-0013	208.00	0.9756	-60.
BUS-0022	480.00	0.9756	-30.
BUS-0023	208.00	0.9756	-60.
BUS-0024	480.00	0.9756	-30.
BUS-0025	208.00	0.9756	-60.
BUS-0026	480.00	0.9756	-30.
BUS-0027	208.00	0.9756	-60.
BUS-0028	480.00	0.9756	-30.
BUS-0029	208.00	0.9756	-60.
BUS-0030	480.00	0.9756	-30.
BUS-0031	208.00	0.9756	-60.
BUS-0074	480.00	0.0000	0.
BUS-0075	480.00	0.0000	0.
BUS-0076	480.00	0.9756	-30.
BUS-0077	480.00	0.9756	-30.

BUS-0078	480.00	0.9756	-30.
BUS-0080	480.00	0.0000	0.

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

************* P R E - F A U L T   V O L T A G E   P R O F I L E **************

BUS# NAME	BASE VOLTS	PU VOLTS	ANGLE (D)
BUS-0081	480.00	0.9756	-30
BUS-0085	480.00	0.0000	0.
BUS-0086	480.00	0.9756	-30.
BUS-0091	480.00	0.9756	-30.
BUS-0094	480.00	0.9756	-30.
BUS-0095	208.00	0.9756	-60.
BUS-0096	480.00	0.9756	-30.
BUS-0097	208.00	0.9756	-60.
BUS-0098	208.00	0.9756	-60.
BUS-0114	480.00	0.9756	-30.
BUS-0130	480.00	0.9756	-30.
BUS-0138	480.00	0.0000	0.
BUS-0202	480.00	0.9756	-30.
BUS-0203	480.00	0.9756	-30.
BUS-0204	480.00	0.9756	-30.
BUS-0208	480.00	0.9756	-30.
BUS-0209	480.00	0.9756	-30.
BUS-0216	13200.00	1.0000	0.
BUS-0218	480.00	0.9756	-30.
BUS-0219	480.00	0.9756	-30.

**************** F A U L T   A N A L Y S I S   R E P O R T ****************

FAULT TYPE: 3PH
MODEL INDUCTION MOTOR CONTRIBUTION: YES
MODEL TRANSFORMER TAPS: YES
MODEL TRANSFORMER PHASE SHIFT: YES

===

1LNH1   VOLTAGE BASE LL: 480.0 (VOLTS)
INI. SYM. RMS FAULT CURRENT: 37952.6 / -94. (AMPS/DEG)
THEVENIN EQUIVALENT IMPEDANCE: 1.366 +j 2.774 (PU)
THEVENIN IMPEDANCE X/R RATIO: 2.030

ASYM RMS INTERRUPTING AMPS

1/2 CYCLES	2 CYCLES	3 CYCLES	5 CYCLES	8 CYCLES
39632.9	37952.7	37952.6	37952.6	37952.6

INI. SYM. RMS FAULTED BUS VOLTAGES (PU / DEG)
AT TIME = 0.5 CYCLES
---PHASE A--- ---PHASE B--- ---PHASE C---

```
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0
```

II. ELECTRICAL DEPTH

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
  INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =     0.5 CYCLES
---PHASE A---       ---PHASE B---       ---PHASE C---
          37952.6 / -93.8    37952.5 / 146.2     37952.5 /  26.2

 1LNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---     ---PHASE B---     ---PHASE C---
  1PNH1          480.0  0.2671 / -76.  0.2671 / 164.  0.2671 /  44.
  1LNH1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1PNH1        1LNH1         N17           480. 37952.6/ -94. 37952.5/ 146. 37952.5/  26.

 ------------------------------------------------------------------------------------------
  1LNL1         VOLTAGE BASE LL:                208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    440.3 /  -90. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  533.591 +j 305.804 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.573

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             440.3       440.3       440.3       440.3       440.3

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---       ---PHASE C---
           440.3 / -89.8      440.3 / 150.2       440.3 /  30.2

 1LNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0023       208.0  0.0720 / -88.  0.0720 / 152.  0.0720 /  32.
  1LNL1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
BUS-0023      1LNL1         N19           208.   440.3/ -90.   440.3/ 150.   440.3/  30.

 ------------------------------------------------------------------------------------------

 1LNL2        VOLTAGE BASE LL:              208.0 (VOLTS)
```

INI. SYM. RMS FAULT CURRENT: 325.3 / -82. (AMPS/DEG)
THEVENIN EQUIVALENT IMPEDANCE: 770.638 +j 314.627 (PU)
THEVENIN IMPEDANCE X/R RATIO: 0.408

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
ASYM   RMS   INTERRUPTING AMPS
     1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
        325.3        325.3        325.3        325.3        325.3
     INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
          AT TIME =     0.5 CYCLES
     ---PHASE A---       ---PHASE B---       ---PHASE C---
     0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

     INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
          AT TIME =     0.5 CYCLES
     ---PHASE A---       ---PHASE B---       ---PHASE C---
      325.3 / -82.2       325.3 / 157.8       325.3 /  37.8

 1LNL2         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0013        208.0  0.3346 / -80.  0.3346 / 160.  0.3346 /  40.
  1LNL2         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
BUS-0013      1LNL2         N18            208.   325.3/ -82.   325.3/ 158.   325.3/  38.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

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--------------------------------------------------------------------------------------------

   1LVSG1       VOLTAGE BASE LL:             480.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:      0.0 /    0. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
           THEVENIN IMPEDANCE X/R RATIO:     0.000

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                0.0        0.0        0.0        0.0        0.0

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                 AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                 AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---       ---PHASE C---
              0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

  1LVSG1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   ---PHASE A---     ---PHASE B---     ---PHASE C---
   1SWBDG1        480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0074       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0075       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0080       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0085       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   1LVSG1       =============== INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ===============
                      FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
1SWBDG1    1LVSG1     E3        480.   0.0/  0.   0.0/  0.   0.0/  0.
1LVSG1     BUS-0074   S1        480.   0.0/  0.   0.0/  0.   0.0/  0.
1LVSG1     BUS-0075   S2        480.   0.0/  0.   0.0/  0.   0.0/  0.
1LVSG1     BUS-0080   E5        480.   0.0/  0.   0.0/  0.   0.0/  0.
1LVSG1     BUS-0085   O1        480.   0.0/  0.   0.0/  0.   0.0/  0.

-------------------------------------------------------------------------------------------

1PBP1      VOLTAGE BASE LL:           480.0 (VOLTS)
       INI. SYM. RMS FAULT CURRENT:  33576.9 /  -98. ( AMPS/DEG )
       THEVENIN EQUIVALENT IMPEDANCE:    1.301 +j   3.244 (PU)
       THEVENIN IMPEDANCE X/R RATIO:     2.493

        ASYM    RMS   INTERRUPTING AMPS
       1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
         36176.3     33578.3     33576.9     33576.9     33576.9

       INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
            AT TIME =     0.5 CYCLES
       ---PHASE A---      ---PHASE B---      ---PHASE C---
       0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

       INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
            AT TIME =     0.5 CYCLES
       ---PHASE A---      ---PHASE B---      ---PHASE C---
       33576.9 / -98.1    33576.9 / 141.9    33576.9 /  21.9

1PBP1      ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
             ---PHASE A---    ---PHASE B---    ---PHASE C---
 1USSHV1     480.0  0.4335 / -54.  0.4335 /-174.  0.4335 /  66.
 BUS-0026    480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 BUS-0028    480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 BUS-0030    480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 BUS-0091    480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 6LNH1       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 5LNH1       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 4LNH1       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 3LNH1       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 1PBP1      ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
              BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1USSHV1    1PBP1      N1        480. 33576.9/ -98. 33576.9/ 142. 33576.9/  22.
1PBP1      BUS-0026   N33       480.   0.0/  0.   0.0/  0.   0.0/  0.
1PBP1      BUS-0028   N45       480.   0.0/  0.   0.0/  0.   0.0/  0.
1PBP1      BUS-0030   N27       480.   0.0/  0.   0.0/  0.   0.0/  0.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
1PBP1      ================  FIRST BUS FROSYSTEM BRANCH FLOWS ( AMPS ) ================

 1PBP1      BUS-0091     N21          480.   0.0/  0.   0.0/  0.   0.0/  0.
 1PBP1      6LNH1        N28          480.   0.0/  0.   0.0/  0.   0.0/  0.
 1PBP1      5LNH1        N29          480.   0.0/  0.   0.0/  0.   0.0/  0.
 1PBP1      4LNH1        N30          480.   0.0/  0.   0.0/  0.   0.0/  0.
 1PBP1      3LNH1        N31          480.   0.0/  0.   0.0/  0.   0.0/  0.

 ---------------------------------------------------------------------------------------------

  1PEH1       VOLTAGE BASE LL:              480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:  31185.2 /  -90. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:    1.910 +j   3.242 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     1.698

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            31946.4     31185.2     31185.2     31185.2     31185.2

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          31185.2 / -89.5    31185.2 / 150.5     31185.2 /  30.5

  1PEH1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---    ---PHASE B---    ---PHASE C---
   BUS-0208       480.0  0.1808 / -55.  0.1808 /-175.  0.1808 /  65.
   1PEH1       ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
 BUS-0208      1PEH1        E6           480. 31185.2/ -90. 31185.2/ 150. 31185.2/  30.

 ---------------------------------------------------------------------------------------------


  1PNH1       VOLTAGE BASE LL:              480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:  45573.4 / -107. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:    0.561 +j   2.513 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     4.481

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            55667.8     45740.1     45583.5     45573.4     45573.4
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          AT TIME =    0.5 CYCLES
        ---PHASE A---      ---PHASE B---      ---PHASE C---
        0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

        INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
            AT TIME =    0.5 CYCLES
        ---PHASE A---      ---PHASE B---      ---PHASE C---
        45573.4 /-107.4    45573.4 / 132.6     45573.4 /  12.6

 1PNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
               ---PHASE A---     ---PHASE B---     ---PHASE C---
  1USSHV1        480.0  0.1943 / -63.  0.1943 / 177.  0.1943 /  57.
  BUS-0012       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0022       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0024       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  2LNH1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  1LNH1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0219       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  1PNH1         ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1USSHV1     1PNH1        N2          480. 45573.4/-107. 45573.4/ 133. 45573.4/  13.
1PNH1       BUS-0012     N13         480.     0.0/   0.     0.0/   0.     0.0/   0.
1PNH1       BUS-0022     N14         480.     0.0/   0.     0.0/   0.     0.0/   0.
1PNH1       BUS-0024     N15         480.     0.0/   0.     0.0/   0.     0.0/   0.
1PNH1       2LNH1        N16         480.     0.0/   0.     0.0/   0.     0.0/   0.
1PNH1       1LNH1        N17         480.     0.0/   0.     0.0/   0.     0.0/   0.


  1PNH1         ================  FIRST BUS FROSYSTEM BRANCH FLOWS ( AMPS ) ================

1PNH1       BUS-0219     N58         480.     0.0/   0.     0.0/   0.     0.0/   0.

-----------------------------------------------------------------------------------------------

 1PNH2        VOLTAGE BASE LL:               480.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:  38791.1 / -100. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:    1.042 +j   2.840 (PU)
        THEVENIN IMPEDANCE X/R RATIO:     2.726

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
          42486.7      38794.9      38791.1      38791.1      38791.1

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
            AT TIME =    0.5 CYCLES
        ---PHASE A---      ---PHASE B---      ---PHASE C---
        0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0
```

II V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          AT TIME =    0.5 CYCLES
      ---PHASE A---     ---PHASE B---     ---PHASE C---
      38791.1 / -99.9   38791.1 / 140.1   38791.1 /  20.1

 1PNH2       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
            ---PHASE A---   ---PHASE B---   ---PHASE C---
  1USSHV1      480.0  0.3515 / -61.  0.3515 / 179.  0.3515 /  59.
  1PNH2       ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
               FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
               BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1USSHV1     1PNH2       N4          480. 38791.1/-100. 38791.1/ 140. 38791.1/  20.

-------------------------------------------------------------------------------------------

 1PNH3       VOLTAGE BASE LL:             480.0 (VOLTS)
      INI. SYM. RMS FAULT CURRENT:  37048.0 /  -98. ( AMPS/DEG )
      THEVENIN EQUIVALENT IMPEDANCE:    1.169 +j   2.944 (PU)
      THEVENIN IMPEDANCE X/R RATIO:     2.518

       ASYM    RMS   INTERRUPTING AMPS
      1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
        39986.0     37049.7     37048.0     37048.0     37048.0

      INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
          AT TIME =    0.5 CYCLES
      ---PHASE A---     ---PHASE B---     ---PHASE C---
      0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

      INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
          AT TIME =    0.5 CYCLES
      ---PHASE A---     ---PHASE B---     ---PHASE C---
      37048.0 / -98.3   37048.0 / 141.7   37048.0 /  21.7

 1PNH3       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
            ---PHASE A---   ---PHASE B---   ---PHASE C---
  1USSHV1      480.0  0.3863 / -59.  0.3863 /-179.  0.3863 /  61.
  1PNH3       ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
               FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
               BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1USSHV1     1PNH3       N5          480. 37048.0/ -98. 37048.0/ 142. 37048.0/  22.

-------------------------------------------------------------------------------------------

 1PNH4       VOLTAGE BASE LL:             480.0 (VOLTS)
      INI. SYM. RMS FAULT CURRENT:  37314.4 /  -99. ( AMPS/DEG )
      THEVENIN EQUIVALENT IMPEDANCE:    1.149 +j   2.927 (PU)
      THEVENIN IMPEDANCE X/R RATIO:     2.548
```

ASYM RMS INTERRUPTING AMPS

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
  40358.1    37316.4    37314.4    37314.4    37314.4

INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
     AT TIME =    0.5 CYCLES
---PHASE A---    ---PHASE B---    ---PHASE C---
0.0000 /   0.0   0.0000 /   0.0   0.0000 /   0.0

INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
     AT TIME =    0.5 CYCLES
---PHASE A---    ---PHASE B---    ---PHASE C---
37314.4 / -98.6   37314.4 / 141.4   37314.4 /  21.4

1PNH4       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
             ---PHASE A---    ---PHASE B---    ---PHASE C---
 1USSHV1       480.0  0.3810 / -59.  0.3810 /-179.  0.3810 /  61.
 1PNH4       =============== INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ===============
               FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
               BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1USSHV1      1PNH4       N6          480. 37314.4/ -99. 37314.4/ 141. 37314.4/  21.

--------------------------------------------------------------------------------------------

1POH1       VOLTAGE BASE LL:             480.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:  39185.3 / -104. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:    0.803 +j   2.885 (PU)
        THEVENIN IMPEDANCE X/R RATIO:     3.593

         ASYM   RMS   INTERRUPTING AMPS
        1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
          45496.4    39221.3    39186.4    39185.3    39185.3

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
             AT TIME =    0.5 CYCLES
        ---PHASE A---    ---PHASE B---    ---PHASE C---
        0.0000 /   0.0   0.0000 /   0.0   0.0000 /   0.0

        INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
             AT TIME =    0.5 CYCLES
        ---PHASE A---    ---PHASE B---    ---PHASE C---
        39185.3 /-104.4   39185.3 / 135.6   39185.3 /  15.6

1POH1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
             ---PHASE A---    ---PHASE B---    ---PHASE C---
 BUS-0086      480.0  0.0826 / -60.  0.0826 /-180.  0.0826 /  60.
 1POH2        480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
 1POH3        480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
```

1POH1 ================ INI. RMS SYSTEM BRANCH FLOWS (AMPS) ================

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D))

FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES

		BRANCH NAME	VBASE LL	-PHASE A-	-PHASE B-	-PHASE C-
BUS-0086	1POH1	O2	480.	39185.3/-104.	39185.3/ 136.	39185.3/ 16.
1POH1	1POH2	O4	480.	0.0/ 0.	0.0/ 0.	0.0/ 0.
1POH1	1POH3	O3	480.	0.0/ 0.	0.0/ 0.	0.0/ 0.

1POH2 VOLTAGE BASE LL: 480.0 (VOLTS)
INI. SYM. RMS FAULT CURRENT: 15683.9 / -67. (AMPS/DEG)
THEVENIN EQUIVALENT IMPEDANCE: 5.942 +j 4.547 (PU)
THEVENIN IMPEDANCE X/R RATIO: 0.765

ASYM RMS INTERRUPTING AMPS

1/2 CYCLES	2 CYCLES	3 CYCLES	5 CYCLES	8 CYCLES
15688.1	15683.9	15683.9	15683.9	15683.9

INI. SYM. RMS FAULTED BUS VOLTAGES (PU / DEG)
AT TIME = 0.5 CYCLES

---PHASE A---	---PHASE B---	---PHASE C---
0.0000 / 0.0	0.0000 / 0.0	0.0000 / 0.0

INI. RMS FAULTED CURRENT (AMPS / DEG)
AT TIME = 0.5 CYCLES

---PHASE A---	---PHASE B---	---PHASE C---
15683.9 / -67.4	15683.8 / 172.6	15683.8 / 52.6

1POH2 ==== INI. SYM. RMS SYSTEM BUS VOLTAGES (PU / DEG) =======
FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES

		---PHASE A---	---PHASE B---	---PHASE C---
1POH1	480.0	0.7043 / -50.	0.7043 /-170.	0.7043 / 70.

1POH2 ================ INI. RMS SYSTEM BRANCH FLOWS (AMPS) ================
FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES

		BRANCH NAME	VBASE LL	-PHASE A-	-PHASE B-	-PHASE C-
1POH1	1POH2	O4	480.	15683.9/ -67.	15683.8/ 173.	15683.8/ 53.

1POH3 VOLTAGE BASE LL: 480.0 (VOLTS)
INI. SYM. RMS FAULT CURRENT: 36131.6 / -102. (AMPS/DEG)
THEVENIN EQUIVALENT IMPEDANCE: 1.008 +j 3.087 (PU)
THEVENIN IMPEDANCE X/R RATIO: 3.063

ASYM RMS INTERRUPTING AMPS

1/2 CYCLES	2 CYCLES	3 CYCLES	5 CYCLES	8 CYCLES
40511.5	36141.5	36131.8	36131.6	36131.6

INI. SYM. RMS FAULTED BUS VOLTAGES (PU / DEG)
AT TIME = 0.5 CYCLES

```
---PHASE A---      ---PHASE B---      ---PHASE C---
0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          36131.6 /-101.9    36131.6 / 138.1    36131.6 /  18.1

 1POH3        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  1POH1         480.0  0.0865 / -57.  0.0865 /-177.  0.0865 /  63.
  6POH1         480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0094      480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0096      480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  1POH3       ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1POH1        1POH3        O3           480. 36131.6/-102. 36131.6/ 138. 36131.6/  18.
1POH3        6POH1        O11           480.    0.0/   0.     0.0/   0.     0.0/   0.
1POH3        BUS-0094      O16           480.    0.0/   0.     0.0/   0.     0.0/   0.
1POH3        BUS-0096      O14           480.    0.0/   0.     0.0/   0.     0.0/   0.

-----------------------------------------------------------------------------------------

 1PSH1       VOLTAGE BASE LL:                480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:  12091.6 /  -74. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:    6.990 +j   6.733 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.963

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            12109.3      12091.6      12091.6      12091.6      12091.6

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          12091.6 / -73.9    12091.6 / 166.1    12091.6 /  46.1

 1PSH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0130      480.0  0.6939 / -39.  0.6939 /-159.  0.6939 /  81.
  1PSH1       ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
```

```
BUS-0130      1PSH1        S4           480. 12091.6/ -74. 12091.6/ 166. 12091.6/  46.

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```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
  INI. SYM. RMS FAULT CURRENT:      0.0 /    0. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
            THEVENIN IMPEDANCE X/R RATIO:     0.000

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                  0.0         0.0         0.0         0.0         0.0

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                   AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
            0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                   AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
               0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

 1SWBDG1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    ---PHASE A---     ---PHASE B---     ---PHASE C---
  1LVSG1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0138         480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  1SWBDG1         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                      FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1SWBDG1       1LVSG1        E3            480.     0.0/   0.     0.0/   0.     0.0/   0.
BUS-0138      1SWBDG1       E1 NEED LENGTH   480.     0.0/   0.     0.0/   0.     0.0/   0.

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 1USSHV1       VOLTAGE BASE LL:                480.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:  54283.3 / -115. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:    0.196 +j   2.153 (PU)
            THEVENIN IMPEDANCE X/R RATIO:    10.993

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              79210.4     59545.8     56014.7     54461.8     54289.0

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                   AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
            0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
1USSHV1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
   1PNH4          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   2PNH1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   1PNH1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0076       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0077       480.0  0.0093 / -80.  0.0093 / 160.  0.0093 /  40.
   BUS-0078       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0081       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   1PBP1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   1PNH3          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   1PNH2          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0209       480.0  0.0290 / -56.  0.0290 /-176.  0.0290 /  64.
   BUS-0218       480.0  0.0142 / -54.  0.0142 /-174.  0.0142 /  66.

   1USSHV1      ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1USSHV1     1PNH4      N6        480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     2PNH1      N3        480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     1PNH1      N2        480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     BUS-0076   N12       480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     BUS-0077   N11       480.   797.5/  69.   797.5/ -51.   797.5/-171.
1USSHV1     BUS-0078   N10       480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     BUS-0081   N9        480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     1PBP1      N1        480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     1PNH3      N5        480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     1PNH2      N4        480.     0.0/   0.     0.0/   0.     0.0/   0.
1USSHV1     BUS-0209   N8        480.  1450.9/  66.  1450.9/ -54.  1450.9/-174.
BUS-0218    1USSHV1    BUS       480. 52036.7/-115. 52036.6/ 125. 52036.7/   5.

---------------------------------------------------------------------------------------------

 2LNH1       VOLTAGE BASE LL:               480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:  19663.0 /  -70. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:    4.589 +j   3.816 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.832

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            19673.3     19663.0     19663.0     19663.0     19663.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
19663.0 / -69.7    19663.0 / 170.3     19663.0 /  50.3

 2LNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  1PNH1          480.0  0.6920 / -52.  0.6920 /-172.  0.6920 /  68.
  2LNH1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PNH1        2LNH1         N16           480. 19663.0/ -70. 19663.0/ 170. 19663.0/  50.

-------------------------------------------------------------------------------------------

 2LNL1        VOLTAGE BASE LL:               208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    451.0 /  -91. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  516.845 +j 305.702 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.591

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             451.0       451.0       451.0       451.0       451.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           451.0 / -90.6      451.0 / 149.4       451.0 /  29.4

 2LNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0025        208.0  0.0466 / -87.  0.0466 / 153.  0.0466 /  33.
  2LNL1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
BUS-0025      2LNL1         N20            208.   451.0/ -91.   451.0/ 149.   451.0/  29.

-------------------------------------------------------------------------------------------

 2PNH1        VOLTAGE BASE LL:               480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:  31858.9 /  -97. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:    1.447 +j   3.387 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     2.341
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            33965.4     31859.6     31858.9     31858.9     31858.9

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          31858.9 / -96.9    31858.9 / 143.1     31858.9 /  23.1

 2PNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---     ---PHASE B---     ---PHASE C---
  1USSHV1         480.0  0.4655 / -52.  0.4655 /-172.  0.4655 /  68.
  3PNH1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  6PNH1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  2PNH1         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1USSHV1      2PNH1         N3            480. 31858.9/ -97. 31858.9/ 143. 31858.9/  23.
2PNH1        3PNH1         N55           480.    0.0/   0.     0.0/   0.     0.0/   0.
2PNH1        6PNH1         N56           480.    0.0/   0.     0.0/   0.     0.0/   0.

-----------------------------------------------------------------------------------------------

 3LNH1        VOLTAGE BASE LL:               480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:  27063.5 /  -86. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:   2.412 +j   3.603 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     1.494

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            27463.7     27063.5     27063.5     27063.5     27063.5

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          27063.5 / -86.2    27063.5 / 153.8     27063.5 /  33.8

 3LNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
    1PBP1          480.0  0.2628 / -68.  0.2628 / 172.  0.2628 /  52.
   3LNH1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PBP1        3LNH1        N31           480. 27063.5/ -86. 27063.5/ 154. 27063.5/  34.

-----------------------------------------------------------------------------------------------

 3LNL1        VOLTAGE BASE LL:              208.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:    442.8 /  -90. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  528.712 +j 307.427 (PU)
           THEVENIN IMPEDANCE X/R RATIO:     0.581

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              442.8       442.8       442.8       442.8       442.8

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
            442.8 / -90.2       442.8 / 149.8       442.8 /  29.8

 3LNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
   3PNL1           208.0  0.0064 / -72.  0.0064 / 168.  0.0064 /  48.
   3LNL1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
3PNL1        3LNL1        N23           208.   442.8/ -90.   442.8/ 150.   442.8/  30.

-----------------------------------------------------------------------------------------------

 3LNL2        VOLTAGE BASE LL:              208.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:    414.7 /  -89. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  568.949 +j 320.441 (PU)
           THEVENIN IMPEDANCE X/R RATIO:     0.563

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              414.7       414.7       414.7       414.7       414.7

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
            0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---      ---PHASE C---
             414.7 / -89.4      414.7 / 150.6      414.7 /  30.6

 3LNL2        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   ---PHASE A---    ---PHASE B---    ---PHASE C---
  3PNL1            208.0  0.0692 / -71.  0.0692 / 169.  0.0692 /  49.
  3LNL2        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
3PNL1        3LNL2        N24             208.   414.7/ -89.   414.7/ 151.   414.7/  31.

--------------------------------------------------------------------------------------------

 3LNL3        VOLTAGE BASE LL:               208.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:    419.2 /  -90. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:  562.144 +j 318.240 (PU)
            THEVENIN IMPEDANCE X/R RATIO:     0.566

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                419.2       419.2       419.2       419.2       419.2

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---      ---PHASE C---
            0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---      ---PHASE C---
             419.2 / -89.5      419.2 / 150.5      419.2 /  30.5

 3LNL3        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   ---PHASE A---    ---PHASE B---    ---PHASE C---
  3PNL1            208.0  0.0592 / -72.  0.0592 / 168.  0.0592 /  48.
  3LNL3        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
3PNL1        3LNL3        N25             208.   419.2/ -90.   419.2/ 150.   419.2/  30.

--------------------------------------------------------------------------------------------

 3LNL4        VOLTAGE BASE LL:               208.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:    423.5 /  -90. ( AMPS/DEG )
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
THEVENIN IMPEDANCE X/R RATIO:     0.569

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
               423.5       423.5       423.5       423.5       423.5

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
            0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
             423.5 / -89.6      423.5 / 150.4       423.5 /  30.4

 3LNL4        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   ---PHASE A---     ---PHASE B---     ---PHASE C---
  3PNL1            208.0  0.0496 / -72.  0.0496 / 168.  0.0496 /  48.
  3LNL4         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                      FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                      BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-     -PHASE C-
3PNL1        3LNL4         N26            208.   423.5/ -90.   423.5/ 150.   423.5/  30.

-----------------------------------------------------------------------------------------------

 3PNH1        VOLTAGE BASE LL:              480.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:   9856.1 /  -74. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:   8.562 +j   8.273 (PU)
            THEVENIN IMPEDANCE X/R RATIO:     0.966

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              9870.8      9856.1      9856.1      9856.1      9856.1

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
            0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
             9856.1 / -74.0     9856.1 / 166.0      9856.1 /  46.0

 3PNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   ---PHASE A---     ---PHASE B---     ---PHASE C---
  2PNH1            480.0  0.7073 / -40.  0.7073 /-160.  0.7073 /  80.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES
BRANCH NAME VBASE LL -PHASE A- -PHASE B- -PHASE C-
2PNH1 3PNH1 N55 480. 9856.1/ -74. 9856.1/ 166. 9856.1/ 46.

3PNL1 VOLTAGE BASE LL: 208.0 (VOLTS)
INI. SYM. RMS FAULT CURRENT: 445.7 / -90. (AMPS/DEG)
THEVENIN EQUIVALENT IMPEDANCE: 524.866 +j 306.183 (PU)
THEVENIN IMPEDANCE X/R RATIO: 0.583

ASYM RMS INTERRUPTING AMPS
1/2 CYCLES 2 CYCLES 3 CYCLES 5 CYCLES 8 CYCLES
445.7 445.7 445.7 445.7 445.7

INI. SYM. RMS FAULTED BUS VOLTAGES (PU / DEG)
AT TIME = 0.5 CYCLES
---PHASE A--- ---PHASE B--- ---PHASE C---
0.0000 / 0.0 0.0000 / 0.0 0.0000 / 0.0

INI. RMS FAULTED CURRENT (AMPS / DEG)
AT TIME = 0.5 CYCLES
---PHASE A--- ---PHASE B--- ---PHASE C---
445.7 / -90.3 445.7 / 149.7 445.7 / 29.7

3PNL1 ==== INI. SYM. RMS SYSTEM BUS VOLTAGES (PU / DEG) =======
FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES
---PHASE A--- ---PHASE B--- ---PHASE C---
BUS-0098 208.0 0.0694 / -88. 0.0694 / 152. 0.0694 / 32.
3LNL1 208.0 0.0000 / 0. 0.0000 / 0. 0.0000 / 0.
3LNL2 208.0 0.0000 / 0. 0.0000 / 0. 0.0000 / 0.
3LNL3 208.0 0.0000 / 0. 0.0000 / 0. 0.0000 / 0.
3LNL4 208.0 0.0000 / 0. 0.0000 / 0. 0.0000 / 0.
3PNL1 ================ INI. RMS SYSTEM BRANCH FLOWS (AMPS) ================
FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES
BRANCH NAME VBASE LL -PHASE A- -PHASE B- -PHASE C-
BUS-0098 3PNL1 N22 208. 445.7/ -90. 445.7/ 150. 445.7/ 30.
3PNL1 3LNL1 N23 208. 0.0/ 0. 0.0/ 0. 0.0/ 0.
3PNL1 3LNL2 N24 208. 0.0/ 0. 0.0/ 0. 0.0/ 0.
3PNL1 3LNL3 N25 208. 0.0/ 0. 0.0/ 0. 0.0/ 0.
3PNL1 3LNL4 N26 208. 0.0/ 0. 0.0/ 0. 0.0/ 0.

4LNH1 VOLTAGE BASE LL: 480.0 (VOLTS)
INI. SYM. RMS FAULT CURRENT: 27063.5 / -86. (AMPS/DEG)
THEVENIN EQUIVALENT IMPEDANCE: 2.412 +j 3.603 (PU)
THEVENIN IMPEDANCE X/R RATIO: 1.49

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
   1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
         27463.7     27063.5     27063.5     27063.5     27063.5

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        27063.5 / -86.2    27063.5 / 153.8     27063.5 /  33.8

 4LNH1         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT     AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  1PBP1          480.0  0.2628 / -68.  0.2628 / 172.  0.2628 /  52.
  4LNH1         =============== INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ===============
                    FIRST BUS FROM FAULT     AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PBP1        4LNH1        N30           480. 27063.5/ -86. 27063.5/ 154. 27063.5/  34.

-----------------------------------------------------------------------------------------

 4LNL1        VOLTAGE BASE LL:               208.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:    457.1 /  -91. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  506.952 +j 306.574 (PU)
        THEVENIN IMPEDANCE X/R RATIO:     0.605

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
           457.1       457.1       457.1       457.1       457.1

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
         457.1 / -91.2      457.1 / 148.8       457.1 /  28.8
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
4LNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  4PNL1          208.0  0.0064 / -73.  0.0064 / 167.  0.0064 /  47.
  4LNL1        ================ INI.    RMS    SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
 4PNL1        4LNL1        N35            208.   457.1/ -91.   457.1/ 149.   457.1/  29.

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 4LNL10        VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    452.0 /  -91. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  513.461 +j 308.680 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.601

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              452.0       452.0       452.0       452.0       452.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---       ---PHASE C---
          0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---       ---PHASE C---
           452.0 / -91.0      452.0 / 149.0       452.0 /  29.0

 4LNL10        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  4PNL1          208.0  0.0175 / -73.  0.0175 / 167.  0.0175 /  47.
  4LNL10        ================ INI.    RMS    SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
 4PNL1        4LNL10        N44            208.   452.0/ -91.   452.0/ 149.   452.0/  29.

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V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
4LNL2        VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    428.5 /  -90. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  545.562 +j 319.062 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.585

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             428.5       428.5       428.5       428.5       428.5

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           428.5 / -90.3     428.5 / 149.7       428.5 /  29.7

4LNL2        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---     ---PHASE B---     ---PHASE C---
 4PNL1         208.0  0.0686 / -72.  0.0686 / 168.  0.0686 /  48.
 4LNL2         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
4PNL1        4LNL2        N36            208.   428.5/ -90.   428.5/ 150.   428.5/  30.

------------------------------------------------------------------------------------------------

4LNL3        VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    430.4 /  -90. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  542.751 +j 318.153 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.586

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             430.5       430.4       430.4       430.4       430.4

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           430.4 / -90.4     430.4 / 149.6       430.4 /  29.6
```

4LNL3 ==== INI. SYM. RMS SYSTEM BUS VOLTAGES (PU / DEG) =======
FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

---PHASE A--- ---PHASE B--- ---PHASE C---
4PNL1 208.0 0.0644 / -72. 0.0644 / 168. 0.0644 / 48.
4LNL3 ================ INI. RMS SYSTEM BRANCH FLOWS (AMPS) ================
FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES
BRANCH NAME VBASE LL -PHASE A- -PHASE B- -PHASE C-
4PNL1 4LNL3 N37 208. 430.4/ -90. 430.4/ 150. 430.4/ 30.

4LNL4 VOLTAGE BASE LL: 208.0 (VOLTS)
INI. SYM. RMS FAULT CURRENT: 439.2 / -91. (AMPS/DEG)
THEVENIN EQUIVALENT IMPEDANCE: 530.473 +j 314.182 (PU)
THEVENIN IMPEDANCE X/R RATIO: 0.592

ASYM RMS INTERRUPTING AMPS
1/2 CYCLES 2 CYCLES 3 CYCLES 5 CYCLES 8 CYCLES
439.2 439.2 439.2 439.2 439.2

INI. SYM. RMS FAULTED BUS VOLTAGES (PU / DEG)
AT TIME = 0.5 CYCLES
---PHASE A--- ---PHASE B--- ---PHASE C---
0.0000 / 0.0 0.0000 / 0.0 0.0000 / 0.0

INI. RMS FAULTED CURRENT (AMPS / DEG)
AT TIME = 0.5 CYCLES
---PHASE A--- ---PHASE B--- ---PHASE C---
439.2 / -90.6 439.2 / 149.4 439.2 / 29.4

4LNL4 ==== INI. SYM. RMS SYSTEM BUS VOLTAGES (PU / DEG) =======
FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES
---PHASE A--- ---PHASE B--- ---PHASE C---
4PNL1 208.0 0.0453 / -73. 0.0453 / 167. 0.0453 / 47.
4LNL4 ================ INI. RMS SYSTEM BRANCH FLOWS (AMPS) ================
FIRST BUS FROM FAULT AT TIME = 0.5 CYCLES
BRANCH NAME VBASE LL -PHASE A- -PHASE B- -PHASE C-
4PNL1 4LNL4 N38 208. 439.2/ -91. 439.2/ 149. 439.2/ 29.

4LNL5 VOLTAGE BASE LL: 208.0 (VOLTS)
INI. SYM. RMS FAULT CURRENT: 446.9 / -91. (AMPS/DEG)
THEVENIN EQUIVALENT IMPEDANCE: 520.118 +j 310.833 (PU)
THEVENIN IMPEDANCE X/R RATIO: 0.598

ASYM RMS INTERRUPTING AMPS
1/2 CYCLES 2 CYCLES 3 CYCLES 5 CYCLES 8 CYCLES
446.9 446.9 446.9 446.9 446.9

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
            0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
             446.9 / -90.9      446.9 / 149.1       446.9 /  29.1

  4LNL5        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
                 FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     ---PHASE A---     ---PHASE B---     ---PHASE C---
   4PNL1            208.0  0.0285 / -73.  0.0285 / 167.  0.0285 /  47.
   4LNL5        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                        FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                        BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
 4PNL1         4LNL5         N39            208.   446.9/ -91.   446.9/ 149.   446.9/  29.

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  4LNL6        VOLTAGE BASE LL:               208.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:    443.3 /  -91. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:  525.000 +j 312.411 (PU)
            THEVENIN IMPEDANCE X/R RATIO:     0.595

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                443.3       443.3       443.3       443.3       443.3

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
            0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
             443.3 / -90.8      443.3 / 149.2       443.3 /  29.2

  4LNL6        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
                 FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     ---PHASE A---     ---PHASE B---     ---PHASE C---
   4PNL1            208.0  0.0365 / -73.  0.0365 / 167.  0.0365 /  47.
   4LNL6        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                        FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                        BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
 4PNL1         4LNL6         N40            208.   443.3/ -91.   443.3/ 149.   443.3/  29.

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  4LNL7        VOLTAGE BASE LL:               208.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:    441.6 /  -91. ( AMPS/DEG )
```

THEVENIN EQUIVALENT IMPEDANCE: 527.219 +j 313.129 (PU)

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)
)

THEVENIN IMPEDANCE X/R RATIO: 0.594

```
            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              441.6       441.6       441.6       441.6       441.6

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
           0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
            441.6 / -90.7     441.6 / 149.3      441.6 /  29.3

 4LNL7        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---    ---PHASE B---    ---PHASE C---
  4PNL1          208.0  0.0401 / -73.  0.0401 / 167.  0.0401 /  47.
  4LNL7        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
4PNL1        4LNL7        N41            208.   441.6/ -91.   441.6/ 149.   441.6/  29.

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 4LNL8        VOLTAGE BASE LL:              208.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:    444.9 /  -91. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  522.781 +j 311.694 (PU)
           THEVENIN IMPEDANCE X/R RATIO:     0.596

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              444.9       444.9       444.9       444.9       444.9

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
           0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
            444.9 / -90.8     444.9 / 149.2      444.9 /  29.2

 4LNL8        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
  4LNL8       ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-     -PHASE C-
4PNL1      4LNL8       N42           208.   444.9/ -91.   444.9/ 149.   444.9/  29.

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 4LNL9       VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    453.8 /  -91. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  511.094 +j 307.914 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.602

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              453.9       453.8       453.8       453.8       453.8

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           453.8 / -91.1       453.8 / 148.9       453.8 /  28.9

 4LNL9       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  4PNL1          208.0  0.0135 / -73.  0.0135 / 167.  0.0135 /  47.
  4LNL9       ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-     -PHASE C-
4PNL1      4LNL9       N43           208.   453.8/ -91.   453.8/ 149.   453.8/  29.

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 4PNL1       VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    460.0 /  -91. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  503.254 +j 305.378 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.607

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              460.0       460.0       460.0       460.0       460.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
---PHASE A---      ---PHASE B---      ---PHASE C---
            460.0 / -91.2     460.0 / 148.8      460.0 /  28.8

 4PNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  4LNL1          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0027        208.0  0.0358 / -89.  0.0358 / 151.  0.0358 /  31.
  4LNL2          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  4LNL3          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  4LNL4          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  4LNL5          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  4LNL6          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  4LNL7          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  4LNL8          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  4LNL9          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  4LNL10          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.

  4PNL1        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
4PNL1       4LNL1       N35          208.    0.0/   0.     0.0/   0.     0.0/   0.
BUS-0027     4PNL1        N34          208.   460.0/ -91.   460.0/ 149.   460.0/  29.
4PNL1       4LNL2       N36          208.    0.0/   0.     0.0/   0.     0.0/   0.
4PNL1       4LNL3       N37          208.    0.0/   0.     0.0/   0.     0.0/   0.
4PNL1       4LNL4       N38          208.    0.0/   0.     0.0/   0.     0.0/   0.
4PNL1       4LNL5       N39          208.    0.0/   0.     0.0/   0.     0.0/   0.
4PNL1       4LNL6       N40          208.    0.0/   0.     0.0/   0.     0.0/   0.
4PNL1       4LNL7       N41          208.    0.0/   0.     0.0/   0.     0.0/   0.
4PNL1       4LNL8       N42          208.    0.0/   0.     0.0/   0.     0.0/   0.
4PNL1       4LNL9       N43          208.    0.0/   0.     0.0/   0.     0.0/   0.
4PNL1       4LNL10       N44          208.    0.0/   0.     0.0/   0.     0.0/   0.

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 4POL1        VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    461.1 /  -91. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  501.743 +j 305.177 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.608

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             461.1       461.1       461.1       461.1       461.1

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
INI.   RMS   FAULTED CURRENT ( AMPS / DEG )                    AT TIME =     0.5 CYCLES

          ---PHASE A---      ---PHASE B---      ---PHASE C---
           461.1 / -91.3     461.1 / 148.7      461.1 /  28.7

4POL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---    ---PHASE B---    ---PHASE C---
 BUS-0095       208.0  0.0359 / -89.  0.0359 / 151.  0.0359 /  31.
 4POL1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
BUS-0095     4POL1        O17          208.   461.1/ -91.   461.1/ 149.   461.1/  29.

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5LNH1        VOLTAGE BASE LL:              480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:  27063.5 /  -86. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:    2.412 +j   3.603 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     1.494

          ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            27463.7     27063.5     27063.5     27063.5     27063.5

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          27063.5 / -86.2    27063.5 / 153.8     27063.5 /  33.8

5LNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---    ---PHASE B---    ---PHASE C---
 1PBP1          480.0  0.2628 / -68.  0.2628 / 172.  0.2628 /  52.
 5LNH1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PBP1        5LNH1        N29          480. 27063.5/ -86. 27063.5/ 154. 27063.5/  34.

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5LNL1        VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    404.5 /  -88. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  593.546 +j 309.840 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.522
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
5PNL1        5LNL2        N48           208.   380.1/ -87.   380.1/ 153.   380.1/  33.

5LNL3      VOLTAGE BASE LL:              208.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:    384.0 /  -87. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  627.866 +j 320.940 (PU)
           THEVENIN IMPEDANCE X/R RATIO:     0.511

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              384.0       384.0       384.0       384.0       384.0

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
           0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
            384.0 / -87.1      384.0 / 152.9      384.0 /  32.9

 5LNL3        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  5PNL1          208.0  0.0555 / -69.  0.0555 / 171.  0.0555 /  51.
  5LNL3        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
5PNL1        5LNL3        N49           208.   384.0/ -87.   384.0/ 153.   384.0/  33.

 -------------------------------------------------------------------------------------------

 5LNL4        VOLTAGE BASE LL:              208.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:    390.8 /  -87. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  616.180 +j 317.160 (PU)
           THEVENIN IMPEDANCE X/R RATIO:     0.515

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              390.8       390.8       390.8       390.8       390.8

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
           0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
  5LNL4        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  5PNL1          208.0  0.0392 / -69.  0.0392 / 171.  0.0392 /  51.
  5LNL4        =============== INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1       5LNL4       N50           208.   390.8/ -87.   390.8/ 153.   390.8/  33.

----------------------------------------------------------------------------------------------------

 5LNL5       VOLTAGE BASE LL:               208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    396.7 /  -87. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  606.120 +j 313.906 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.518

          ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             396.7       396.7       396.7       396.7       396.7

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           396.7 / -87.4      396.7 / 152.6       396.7 /  32.6

 5LNL5         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  5PNL1          208.0  0.0247 / -69.  0.0247 / 171.  0.0247 /  51.
  5LNL5        =============== INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1       5LNL5       N51           208.   396.7/ -87.   396.7/ 153.   396.7/  33.

----------------------------------------------------------------------------------------------------

 5LNL6       VOLTAGE BASE LL:               208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    387.5 /  -87. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  621.801 +j 318.978 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.513

          ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             387.5       387.5       387.5       387.5       387.5
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
              AT TIME =    0.5 CYCLES
          ---PHASE A---    ---PHASE B---    ---PHASE C---
          0.0000 /   0.0    0.0000 /   0.0    0.0000 /   0.0

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =    0.5 CYCLES
          ---PHASE A---    ---PHASE B---    ---PHASE C---
           387.5 / -87.2    387.5 / 152.8    387.5 /  32.8

 5LNL6     ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
               ---PHASE A---    ---PHASE B---    ---PHASE C---
  5PNL1        208.0  0.0471 / -69.  0.0471 / 171.  0.0471 /  51.
  5LNL6      =============== INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ===============
                  FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1      5LNL6      N52         208.   387.5/ -87.   387.5/ 153.   387.5/  33.

-------------------------------------------------------------------------------------------

 5LNL7      VOLTAGE BASE LL:            208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:   394.5 /  -87. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  609.819 +j 315.103 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.517

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             394.5       394.5       394.5       394.5       394.5

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =    0.5 CYCLES
          ---PHASE A---    ---PHASE B---    ---PHASE C---
          0.0000 /   0.0    0.0000 /   0.0    0.0000 /   0.0

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =    0.5 CYCLES
          ---PHASE A---    ---PHASE B---    ---PHASE C---
           394.5 / -87.3    394.5 / 152.7    394.5 /  32.7

 5LNL7     ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
               ---PHASE A---    ---PHASE B---    ---PHASE C---
  5PNL1        208.0  0.0301 / -69.  0.0301 / 171.  0.0301 /  51.
  5LNL7      =============== INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ===============
                  FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1      5LNL7      N53         208.   394.5/ -87.   394.5/ 153.   394.5/  33.

-------------------------------------------------------------------------------------------
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
        INI. SYM. RMS FAULT CURRENT:    401.8 /  -88. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  597.836 +j 311.227 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.521

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              401.8       401.8       401.8       401.8       401.8

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           401.8 / -87.5       401.8 / 152.5       401.8 /  32.5

 5LNL8         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  5PNL1           208.0  0.0124 / -70.  0.0124 / 170.  0.0124 /  50.
  5LNL8         =============== INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ===============
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1        5LNL8        N54            208.   401.8/ -88.   401.8/ 152.   401.8/  32.

-------------------------------------------------------------------------------------------

 5PNL1        VOLTAGE BASE LL:               208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    406.9 /  -88. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  589.700 +j 308.596 (PU)
          THEVENIN IMPEDANCE X/R RATIO:     0.523

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              406.9       406.9       406.9       406.9       406.9

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           406.9 / -87.6       406.9 / 152.4       406.9 /  32.4

 5PNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
```

---PHASE A--- ---PHASE B--- ---PHASE C---

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
5LNL1          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   BUS-0029       208.0  0.1585 / -85.  0.1585 / 155.  0.1585 /  35.
   5LNL2          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   5LNL3          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   5LNL4          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   5LNL5          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   5LNL6          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   5LNL7          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   5LNL8          208.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
   5PNL1      ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
 5PNL1       5LNL1       N47          208.    0.0/   0.     0.0/   0.     0.0/   0.
 BUS-0029    5PNL1       N46          208.   406.9/ -88.   406.9/ 152.   406.9/  32.
 5PNL1       5LNL2       N48          208.    0.0/   0.     0.0/   0.     0.0/   0.
 5PNL1       5LNL3       N49          208.    0.0/   0.     0.0/   0.     0.0/   0.


   5PNL1      ================  FIRST BUS FROSYSTEM BRANCH FLOWS ( AMPS ) ================

 5PNL1       5LNL4       N50          208.    0.0/   0.     0.0/   0.     0.0/   0.
 5PNL1       5LNL5       N51          208.    0.0/   0.     0.0/   0.     0.0/   0.
 5PNL1       5LNL6       N52          208.    0.0/   0.     0.0/   0.     0.0/   0.
 5PNL1       5LNL7       N53          208.    0.0/   0.     0.0/   0.     0.0/   0.
 5PNL1       5LNL8       N54          208.    0.0/   0.     0.0/   0.     0.0/   0.

 ------------------------------------------------------------------------------------------

  5POL1       VOLTAGE BASE LL:               208.0 (VOLTS)
              INI. SYM. RMS FAULT CURRENT:    461.1 /  -91. ( AMPS/DEG )
              THEVENIN EQUIVALENT IMPEDANCE:  501.743 +j 305.177 (PU)
              THEVENIN IMPEDANCE X/R RATIO:     0.608

               ASYM    RMS   INTERRUPTING AMPS
              1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
                  461.1       461.1      461.1      461.1      461.1

              INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                    AT TIME =    0.5 CYCLES
              ---PHASE A---      ---PHASE B---      ---PHASE C---
              0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

              INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                    AT TIME =    0.5 CYCLES
              ---PHASE A---      ---PHASE B---      ---PHASE C---
               461.1 / -91.3      461.1 / 148.7      461.1 /  28.7

  5POL1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
                 FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
    5POL1          ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                         FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                        BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
BUS-0097       5POL1          O15            208.   461.1/ -91.   461.1/ 149.   461.1/  29.

------------------------------------------------------------------------------------------

 6LNH1         VOLTAGE BASE LL:                480.0 (VOLTS)
             INI. SYM. RMS FAULT CURRENT:  27063.5 /  -86. ( AMPS/DEG )
             THEVENIN EQUIVALENT IMPEDANCE:    2.412 +j   3.603 (PU)
             THEVENIN IMPEDANCE X/R RATIO:     1.494

              ASYM    RMS   INTERRUPTING AMPS
             1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
               27463.7     27063.5     27063.5     27063.5     27063.5

             INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                    AT TIME =     0.5 CYCLES
             ---PHASE A---       ---PHASE B---       ---PHASE C---
             0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

             INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                    AT TIME =     0.5 CYCLES
             ---PHASE A---       ---PHASE B---       ---PHASE C---
             27063.5 / -86.2    27063.5 / 153.8     27063.5 /  33.8

 6LNH1         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
                FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     ---PHASE A---    ---PHASE B---     ---PHASE C---
  1PBP1              480.0  0.2628 / -68.  0.2628 / 172.  0.2628 /  52.
  6LNH1          ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                         FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                        BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PBP1         6LNH1          N28             480. 27063.5/ -86. 27063.5/ 154. 27063.5/  34.

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 6LNL1         VOLTAGE BASE LL:                208.0 (VOLTS)
             INI. SYM. RMS FAULT CURRENT:     419.1 /  -88. ( AMPS/DEG )
             THEVENIN EQUIVALENT IMPEDANCE:  568.089 +j 307.791 (PU)
             THEVENIN IMPEDANCE X/R RATIO:     0.542

              ASYM    RMS   INTERRUPTING AMPS
             1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                 419.1       419.1       419.1       419.1       419.1

             INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                    AT TIME =     0.5 CYCLES
             ---PHASE A---       ---PHASE B---       ---PHASE C---
             0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
            INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
             419.1 / -88.4      419.1 / 151.6       419.1 /  31.6

 6LNL1         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   ---PHASE A---    ---PHASE B---     ---PHASE C---
  BUS-0031       208.0  0.1306 / -86.  0.1306 / 154.  0.1306 /  34.
  6LNL1        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
BUS-0031      6LNL1        N32           208.   419.1/ -88.   419.1/ 152.   419.1/  32.

-----------------------------------------------------------------------------------------------

 6PNH1        VOLTAGE BASE LL:                480.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:   8950.1 /  -73. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:    9.569 +j   8.964 (PU)
            THEVENIN IMPEDANCE X/R RATIO:      0.937

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
               8961.0       8950.1       8950.1       8950.1       8950.1

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
            0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

            INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
             8950.1 / -73.1     8950.0 / 166.9      8950.1 /  46.9

 6PNH1         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   ---PHASE A---    ---PHASE B---     ---PHASE C---
  2PNH1          480.0  0.7331 / -39.  0.7331 /-159.  0.7331 /  81.
  6PNH1        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
2PNH1         6PNH1        N56          480.  8950.1/ -73.  8950.0/ 167.  8950.1/  47.

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 6POH1        VOLTAGE BASE LL:                480.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:  31242.8 /  -94. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:    1.619 +j   3.389 (PU)
            THEVENIN IMPEDANCE X/R RATIO:      2.093
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             32757.8     31243.0     31242.8     31242.8     31242.8

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           31242.8 / -94.5    31242.8 / 145.5     31242.8 /  25.5

 6POH1         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  1POH3          480.0  0.1771 / -68.  0.1771 / 172.  0.1771 /  52.
  6POH1         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1POH3         6POH1         O11            480. 31242.8/ -94. 31242.8/ 146. 31242.8/  26.

------------------------------------------------------------------------------------------

 6PSH1        VOLTAGE BASE LL:               480.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:  12577.4 /  -76. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:    6.441 +j   6.750 (PU)
           THEVENIN IMPEDANCE X/R RATIO:     1.048

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             12608.7     12577.4     12577.4     12577.4     12577.4

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     0.0000 /    0.0     0.0000 /    0.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           12577.4 / -76.3    12577.4 / 163.7     12577.4 /  43.7

 6PSH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0114         480.0  0.6847 / -39.  0.6847 /-159.  0.6847 /  81.
  BUS-0202         480.0  0.0067 /-101.  0.0067 / 139.  0.0067 /  19.
  BUS-0203         480.0  0.0073 /-101.  0.0073 / 139.  0.0073 /  19.
```

```
  BUS-0204        480.0  0.0077 /-101.  0.0077 / 139.  0.0077 /  19.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
  6PSH1        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
BUS-0114     6PSH1        S3            480. 11931.2/ -74. 11931.2/ 166. 11931.2/  46.
6PSH1        BUS-0202     S5            480.   276.2/  66.   276.2/ -54.   276.2/-174.
6PSH1        BUS-0203     S6            480.   276.1/  66.   276.1/ -54.   276.1/-174.
6PSH1        BUS-0204     S7            480.   276.1/  66.   276.1/ -54.   276.1/-174.

-----------------------------------------------------------------------------------------------

***************** F A U L T   A N A L Y S I S   R E P O R T ****************

            FAULT TYPE: SLG
            MODEL INDUCTION MOTOR CONTRIBUTION: YES
            MODEL TRANSFORMER TAPS: YES
            MODEL TRANSFORMER PHASE SHIFT: YES
=============================================================================


 1LNH1        VOLTAGE BASE LL:              480.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
            THEVENIN IMPEDANCE X/R RATIO:     1.001
            SEQUENCE EQUIVALENT IMPEDANCE Z1:   1.366 +j   2.774 (PU)
                                   Z2:   1.366 +j   2.774 (PU)
                                   Z0: INFINITE

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                 0.0         0.0         0.0         0.0         0.0

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
            0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---       ---PHASE B---       ---PHASE C---
               0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

 1LNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---    ---PHASE B---    ---PHASE C---
  1PNH1           480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1LNH1        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PNH1        1LNH1        N17           480.     0.0/ -75.     0.0/   0.     0.0/   0.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
 1LNL1       VOLTAGE BASE LL:            208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:   423.2 /  -89. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:    0.544
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 533.591 +j 305.804 (PU)
                              Z2: 533.591 +j 305.804 (PU)
                              Z0: 619.314 +j 305.339 (PU)

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
             423.2      423.2      423.2      423.2      423.2

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =    0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0000 /   0.0    0.9775 /  177.4    1.0131 /   61.3

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =    0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
           423.2 / -88.5      0.0 /   0.0       0.0 /   0.0

 1LNL1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
               ---PHASE A---    ---PHASE B---    ---PHASE C---
  BUS-0023       208.0  0.1189 / -87.  0.9740 /-180.  0.9712 /  60.
  1LNL1       =============== INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
BUS-0023      1LNL1        N19          208.   423.2/ -89.    0.0/   0.     0.0/   0.

------------------------------------------------------------------------------------------------

 1LNL2       VOLTAGE BASE LL:            208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:   264.7 /  -78. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:    0.328
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 770.638 +j 314.627 (PU)
                              Z2: 770.638 +j 314.627 (PU)
                              Z0: INFINITE

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
             264.7      264.7      264.7      264.7      264.7

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =    0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0000 /   0.0    1.0361 /  169.6    1.1238 /   66.7
```

INI. RMS FAULTED CURRENT (AMPS / DEG)

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
              AT TIME =    0.5 CYCLES
        ---PHASE A---    ---PHASE B---    ---PHASE C---
         264.7 / -78.2      0.0 /   0.0        0.0 /   0.0

 1LNL2        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                ---PHASE A---    ---PHASE B---    ---PHASE C---
  BUS-0013       208.0  0.4673 / -76.  0.9741 /-180.  0.9741 /  60.
  1LNL2        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
BUS-0013      1LNL2         N18            208.   264.7/ -78.    0.0/   0.     0.0/   0.

------------------------------------------------------------------------------------------

 1LVSG1       VOLTAGE BASE LL:              480.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:      0.0 /    0. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     0.000
        SEQUENCE EQUIVALENT IMPEDANCE Z1: INFINITE
                              Z2: INFINITE
                              Z0: INFINITE

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             0.0          0.0          0.0          0.0          0.0

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =    0.5 CYCLES
        ---PHASE A---    ---PHASE B---    ---PHASE C---
        0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

        INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =    0.5 CYCLES
        ---PHASE A---    ---PHASE B---    ---PHASE C---
           0.0 /   0.0        0.0 /   0.0        0.0 /   0.0

 1LVSG1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                ---PHASE A---    ---PHASE B---    ---PHASE C---
  1SWBDG1        480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0074       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0075       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0080       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0085       480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  1LVSG1        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1SWBDG1       1LVSG1        E3             480.     0.0/   0.     0.0/   0.     0.0/   0.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D))

```
1LVSG1       BUS-0080     E5          480.    0.0/   0.    0.0/   0.    0.0/   0.
 1LVSG1       BUS-0085     O1          480.    0.0/   0.    0.0/   0.    0.0/   0.

 ---------------------------------------------------------------------------------------------

  1PBP1        VOLTAGE BASE LL:              480.0 (VOLTS)
              INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
              THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
              THEVENIN IMPEDANCE X/R RATIO:     1.001
              SEQUENCE EQUIVALENT IMPEDANCE Z1:   1.301 +j   3.244 (PU)
                                  Z2:   1.301 +j   3.244 (PU)
                                  Z0: INFINITE

               ASYM    RMS   INTERRUPTING AMPS
              1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                   0.0        0.0        0.0        0.0        0.0

              INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                   AT TIME =     0.5 CYCLES
              ---PHASE A---       ---PHASE B---       ---PHASE C---
              0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

              INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                   AT TIME =     0.5 CYCLES
              ---PHASE A---       ---PHASE B---       ---PHASE C---
                 0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

  1PBP1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
                 FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     ---PHASE A---    ---PHASE B---    ---PHASE C---
   1USSHV1        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   BUS-0026       480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   BUS-0028       480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   BUS-0030       480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   BUS-0091       480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   6LNH1          480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   5LNH1          480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   4LNH1          480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   3LNH1          480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   1PBP1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
 1USSHV1      1PBP1        N1          480.    0.0/ -75.    0.0/   0.    0.0/   0.
 1PBP1       BUS-0026     N33         480.    0.0/   0.    0.0/   0.    0.0/   0.
 1PBP1       BUS-0028     N45         480.    0.0/   0.    0.0/   0.    0.0/   0.
 1PBP1       BUS-0030     N27         480.    0.0/   0.    0.0/   0.    0.0/   0.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
1PBP1      ================ FIRST BUS FROSYSTEM BRANCH FLOWS ( AMPS ) ================

 1PBP1     BUS-0091    N21        480.   0.0/  0.    0.0/  0.    0.0/  0.
 1PBP1     6LNH1       N28        480.   0.0/  0.    0.0/  0.    0.0/  0.
 1PBP1     5LNH1       N29        480.   0.0/  0.    0.0/  0.    0.0/  0.
 1PBP1     4LNH1       N30        480.   0.0/  0.    0.0/  0.    0.0/  0.
 1PBP1     3LNH1       N31        480.   0.0/  0.    0.0/  0.    0.0/  0.

 -------------------------------------------------------------------------------------------

  1PEH1      VOLTAGE BASE LL:              480.0 (VOLTS)
         INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
         THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
         THEVENIN IMPEDANCE X/R RATIO:     1.001
         SEQUENCE EQUIVALENT IMPEDANCE Z1:   1.910 +j   3.242 (PU)
                                       Z2:   1.910 +j   3.242 (PU)
                                       Z0: INFINITE

          ASYM    RMS   INTERRUPTING AMPS
         1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              0.0        0.0        0.0        0.0        0.0

         INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =     0.5 CYCLES
         ---PHASE A---       ---PHASE B---       ---PHASE C---
         0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

         INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =     0.5 CYCLES
         ---PHASE A---       ---PHASE B---       ---PHASE C---
            0.0 /   0.0        0.0 /   0.0        0.0 /   0.0

  1PEH1      ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
           FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
               ---PHASE A---     ---PHASE B---     ---PHASE C---
   BUS-0208      480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   1PEH1      ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                 FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-     -PHASE C-
 BUS-0208     1PEH1       E6          480.   0.0/ -75.    0.0/   0.    0.0/   0.

 -------------------------------------------------------------------------------------------

  1PNH1      VOLTAGE BASE LL:              480.0 (VOLTS)
         INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
         THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
         THEVENIN IMPEDANCE X/R RATIO:     1.001
         SEQUENCE EQUIVALENT IMPEDANCE Z1:   0.561 +j   2.513 (PU)
                                       Z2:   0.561 +j   2.513 (PU)
                                       Z0: INFINITE
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
               0.0         0.0         0.0         0.0         0.0

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
              0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

 1PNH1         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  1USSHV1         480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  BUS-0012        480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0022        480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0024        480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  2LNH1           480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  1LNH1           480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0219        480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  1PNH1         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1USSHV1      1PNH1         N2          480.    0.0/ -75.    0.0/   0.     0.0/   0.
1PNH1        BUS-0012      N13         480.    0.0/   0.    0.0/   0.     0.0/   0.
1PNH1        BUS-0022      N14         480.    0.0/   0.    0.0/   0.     0.0/   0.
1PNH1        BUS-0024      N15         480.    0.0/   0.    0.0/   0.     0.0/   0.
1PNH1        2LNH1         N16         480.    0.0/   0.    0.0/   0.     0.0/   0.
1PNH1        1LNH1         N17         480.    0.0/   0.    0.0/   0.     0.0/   0.

  1PNH1         ================  FIRST BUS FROSYSTEM BRANCH FLOWS ( AMPS ) ================

1PNH1        BUS-0219      N58         480.    0.0/   0.    0.0/   0.     0.0/   0.

-----------------------------------------------------------------------------------------------

 1PNH2        VOLTAGE BASE LL:               480.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
           THEVENIN IMPEDANCE X/R RATIO:     1.001
           SEQUENCE EQUIVALENT IMPEDANCE Z1:   1.042 +j   2.840 (PU)
                                  Z2:   1.042 +j   2.840 (PU)
                                  Z0: INFINITE

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0000 /    0.0    1.6898 / -180.0    1.6898 /  120.0

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
             0.0 /   0.0        0.0 /   0.0        0.0 /   0.0

 1PNH2        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---     ---PHASE B---     ---PHASE C---
  1USSHV1        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1PNH2        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1USSHV1      1PNH2        N4           480.    0.0/ -75.    0.0/   0.    0.0/   0.

 ---------------------------------------------------------------------------------------------

 1PNH3        VOLTAGE BASE LL:               480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     1.001
          SEQUENCE EQUIVALENT IMPEDANCE Z1:   1.169 +j   2.944 (PU)
                                Z2:   1.169 +j   2.944 (PU)
                                Z0: INFINITE

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              0.0        0.0        0.0        0.0        0.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0000 /    0.0    1.6898 / -180.0    1.6898 /  120.0

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
             0.0 /   0.0        0.0 /   0.0        0.0 /   0.0

 1PNH3        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---     ---PHASE B---     ---PHASE C---
  1USSHV1        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1PNH3        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =    0.5 CYCLES
          ---PHASE A---     ---PHASE B---     ---PHASE C---
            0.0 /   0.0       0.0 /   0.0       0.0 /   0.0

 1POH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                ---PHASE A---    ---PHASE B---    ---PHASE C---
  BUS-0086       480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1POH2         480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1POH3         480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1POH1        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
BUS-0086     1POH1        O2           480.    0.0/ -75.    0.0/   0.    0.0/   0.
1POH1       1POH2        O4           480.    0.0/   0.    0.0/   0.    0.0/   0.
1POH1       1POH3        O3           480.    0.0/   0.    0.0/   0.    0.0/   0.

-----------------------------------------------------------------------------------------

 1POH2        VOLTAGE BASE LL:              480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     1.001
          SEQUENCE EQUIVALENT IMPEDANCE Z1:   5.942 +j   4.547 (PU)
                              Z2:   5.942 +j   4.547 (PU)
                              Z0: INFINITE

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              0.0          0.0          0.0          0.0          0.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =    0.5 CYCLES
          ---PHASE A---     ---PHASE B---     ---PHASE C---
          0.0000 /    0.0    1.6898 / -180.0    1.6898 /  120.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =    0.5 CYCLES
          ---PHASE A---     ---PHASE B---     ---PHASE C---
            0.0 /   0.0       0.0 /   0.0       0.0 /   0.0

 1POH2        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                ---PHASE A---    ---PHASE B---    ---PHASE C---
  1POH1         480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1POH2        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1POH1       1POH2        O4           480.    0.0/ -75.    0.0/   0.    0.0/   0.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
1POH3      VOLTAGE BASE LL:            480.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:     0.0 /  -75. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     1.001
        SEQUENCE EQUIVALENT IMPEDANCE Z1:   1.008 +j   3.087 (PU)
                               Z2:   1.008 +j   3.087 (PU)
                               Z0: INFINITE

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
           0.0        0.0        0.0        0.0        0.0

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
           AT TIME =     0.5 CYCLES
        ---PHASE A---      ---PHASE B---      ---PHASE C---
        0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
           AT TIME =     0.5 CYCLES
        ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0 /   0.0       0.0 /   0.0        0.0 /   0.0

 1POH3       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =      0.5 CYCLES
             ---PHASE A---    ---PHASE B---     ---PHASE C---
  1POH1         480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  6POH1         480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  BUS-0094       480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  BUS-0096       480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1POH3       ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                FIRST BUS FROM FAULT    AT TIME =      0.5 CYCLES
                BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
 1POH1       1POH3       O3           480.    0.0/ -75.    0.0/   0.     0.0/   0.
 1POH3       6POH1       O11          480.    0.0/   0.    0.0/   0.     0.0/   0.
 1POH3       BUS-0094     O16          480.    0.0/   0.    0.0/   0.     0.0/   0.
 1POH3       BUS-0096     O14          480.    0.0/   0.    0.0/   0.     0.0/   0.

 ------------------------------------------------------------------------------------------

 1PSH1      VOLTAGE BASE LL:            480.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:     0.0 /  -75. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     1.001
        SEQUENCE EQUIVALENT IMPEDANCE Z1:   6.990 +j   6.733 (PU)
                               Z2:   6.990 +j   6.733 (PU)
                               Z0: INFINITE

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
0.0        0.0        0.0        0.0        0.0

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---       ---PHASE C---
            0.0000 /    0.0    1.6898 / -180.0     1.6898 /  120.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---       ---PHASE C---
               0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

 1PSH1         ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0130        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  1PSH1         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                       FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                       BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
BUS-0130      1PSH1         S4            480.    0.0/ -75.     0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------

 1SWBDG1       VOLTAGE BASE LL:              480.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:      0.0 /    0. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
            THEVENIN IMPEDANCE X/R RATIO:     0.000
            SEQUENCE EQUIVALENT IMPEDANCE Z1: INFINITE
                                      Z2: INFINITE
                                      Z0: INFINITE

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                 0.0        0.0        0.0        0.0        0.0

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---       ---PHASE C---
            0.0000 /    0.0    0.0000 /    0.0    0.0000 /    0.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                  AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---       ---PHASE C---
               0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

 1SWBDG1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    ---PHASE A---     ---PHASE B---     ---PHASE C---
  1LVSG1          480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
  BUS-0138        480.0  0.0000 /   0.  0.0000 /   0.  0.0000 /   0.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1SWBDG1      1LVSG1        E3              480.     0.0/   0.     0.0/   0.     0.0/   0.
BUS-0138     1SWBDG1       E1 NEED LENGTH   480.     0.0/   0.     0.0/   0.     0.0/   0.

--------------------------------------------------------------------------------------------

 1USSHV1       VOLTAGE BASE LL:               480.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
           THEVENIN IMPEDANCE X/R RATIO:     1.001
           SEQUENCE EQUIVALENT IMPEDANCE Z1:   0.196 +j   2.153 (PU)
                                Z2:   0.196 +j   2.153 (PU)
                                Z0: INFINITE

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                0.0         0.0         0.0         0.0         0.0

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
              0.0 /   0.0        0.0 /   0.0        0.0 /   0.0

 1USSHV1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  1PNH4         480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  2PNH1         480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  1PNH1         480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0076      480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0077      480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0078      480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0081      480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  1PBP1         480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  1PNH3         480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  1PNH2         480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0209      480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.
  BUS-0218      480.0  0.0000 /   0.  1.6898 / 180.  1.6898 / 120.

  1USSHV1      ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1USSHV1      1PNH4         N6              480.     0.0/   0.     0.0/   0.     0.0/   0.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
1USSHV1      BUS-0076     N12          480.   0.0/  0.    0.0/  0.    0.0/  0.
1USSHV1      BUS-0077     N11          480.   0.0/  0.    0.0/  0.    0.0/  0.
1USSHV1      BUS-0078     N10          480.   0.0/  0.    0.0/  0.    0.0/  0.
1USSHV1      BUS-0081     N9           480.   0.0/  0.    0.0/  0.    0.0/  0.
1USSHV1      1PBP1        N1           480.   0.0/  0.    0.0/  0.    0.0/  0.
1USSHV1      1PNH3        N5           480.   0.0/  0.    0.0/  0.    0.0/  0.
1USSHV1      1PNH2        N4           480.   0.0/  0.    0.0/  0.    0.0/  0.
1USSHV1      BUS-0209     N8           480.   0.0/  0.    0.0/  0.    0.0/  0.
BUS-0218     1USSHV1      BUS          480.   0.0/ -75.   0.0/  0.    0.0/  0.

-------------------------------------------------------------------------------------------

2LNH1       VOLTAGE BASE LL:              480.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     1.001
        SEQUENCE EQUIVALENT IMPEDANCE Z1:   4.589 +j   3.816 (PU)
                              Z2:   4.589 +j   3.816 (PU)
                              Z0: INFINITE

        ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            0.0         0.0         0.0         0.0         0.0

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        0.0000 /    0.0    1.6898 / -180.0    1.6898 /  120.0

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

2LNH1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
             ---PHASE A---    ---PHASE B---    ---PHASE C---
 1PNH1        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
 2LNH1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PNH1        2LNH1        N16          480.    0.0/ -75.     0.0/   0.     0.0/   0.

-------------------------------------------------------------------------------------------

2LNL1       VOLTAGE BASE LL:              208.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:     440.5 /  -90. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     0.573
        SEQUENCE EQUIVALENT IMPEDANCE Z1: 516.845 +j 305.702 (PU)
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
                              Z0: 566.537 +j 305.087 (PU)

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              440.6       440.5       440.5       440.5       440.5

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     0.9757 /  178.5     0.9986 /   60.7

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
            440.5 / -89.8       0.0 /   0.0         0.0 /   0.0

 2LNL1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0025       208.0  0.0781 / -87.  0.9741 /-180.  0.9709 /  60.
  2LNL1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                   FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
BUS-0025      2LNL1        N20           208.   440.5/ -90.     0.0/   0.     0.0/   0.

--------------------------------------------------------------------------------------------

 2PNH1       VOLTAGE BASE LL:                  480.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
           THEVENIN IMPEDANCE X/R RATIO:     1.001
           SEQUENCE EQUIVALENT IMPEDANCE Z1:   1.447 +j   3.387 (PU)
                              Z2:   1.447 +j   3.387 (PU)
                              Z0: INFINITE

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
               0.0         0.0         0.0         0.0         0.0

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
             0.0 /   0.0       0.0 /   0.0         0.0 /   0.0

 2PNH1       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
   1USSHV1         480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   3PNH1           480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   6PNH1           480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   2PNH1         ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1USSHV1      2PNH1         N3           480.     0.0/ -75.     0.0/   0.     0.0/   0.
2PNH1        3PNH1         N55          480.     0.0/   0.     0.0/   0.     0.0/   0.
2PNH1        6PNH1         N56          480.     0.0/   0.     0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------

 3LNH1        VOLTAGE BASE LL:               480.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
           THEVENIN IMPEDANCE X/R RATIO:     1.001
           SEQUENCE EQUIVALENT IMPEDANCE Z1:   2.412 +j   3.603 (PU)
                                       Z2:   2.412 +j   3.603 (PU)
                                       Z0: INFINITE

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                0.0         0.0         0.0         0.0         0.0

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
           0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---       ---PHASE B---       ---PHASE C---
              0.0 /   0.0        0.0 /   0.0          0.0 /   0.0

 3LNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---    ---PHASE B---    ---PHASE C---
   1PBP1         480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   3LNH1         ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PBP1        3LNH1         N31          480.     0.0/ -75.     0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------

 3LNL1        VOLTAGE BASE LL:               208.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:    423.4 /  -89. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
           THEVENIN IMPEDANCE X/R RATIO:     0.549
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
 ASYM    RMS   INTERRUPTING AMPS
1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
    423.4       423.4       423.4       423.4       423.4

INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
       AT TIME =     0.5 CYCLES
---PHASE A---       ---PHASE B---       ---PHASE C---
0.0000 /    0.0     0.9783 /  177.1     1.0174 /   61.4

INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
       AT TIME =     0.5 CYCLES
---PHASE A---       ---PHASE B---       ---PHASE C---
 423.4 / -88.8       0.0 /   0.0         0.0 /   0.0

3LNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
 3PNL1            208.0  0.0105 / -73.  0.9771 / 177.  1.0142 /  61.
 3LNL1        ================ INI.    RMS    SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
3PNL1        3LNL1         N23            208.   423.4/ -89.    0.0/   0.    0.0/   0.

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3LNL2        VOLTAGE BASE LL:               208.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:    381.6 /  -87. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     0.519
        SEQUENCE EQUIVALENT IMPEDANCE Z1: 568.949 +j 320.441 (PU)
                                      Z2: 568.949 +j 320.441 (PU)
                                      Z0: 751.433 +j 340.235 (PU)

 ASYM    RMS   INTERRUPTING AMPS
1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
    381.6       381.6       381.6       381.6       381.6

INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
       AT TIME =     0.5 CYCLES
---PHASE A---       ---PHASE B---       ---PHASE C---
0.0000 /    0.0     0.9919 /  175.2     1.0425 /   62.9

INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
       AT TIME =     0.5 CYCLES
---PHASE A---       ---PHASE B---       ---PHASE C---
 381.6 / -87.4       0.0 /   0.0         0.0 /   0.0
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
---PHASE A---     ---PHASE B---     ---PHASE C---
   3PNL1          208.0  0.1081 / -72.  0.9777 / 178.  1.0099 /  61.
   3LNL2        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                      FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
 3PNL1        3LNL2         N24            208.   381.6/ -87.    0.0/   0.     0.0/   0.

 ---------------------------------------------------------------------------------------------

 3LNL3        VOLTAGE BASE LL:                208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    388.1 /  -88. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.524
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 562.144 +j 318.240 (PU)
                                  Z2: 562.144 +j 318.240 (PU)
                                  Z0: 729.987 +j 334.818 (PU)

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              388.1        388.1        388.1        388.1        388.1

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.9896 /  175.5     1.0387 /   62.7

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           388.1 / -87.6        0.0 /   0.0         0.0 /   0.0

 3LNL3        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
   3PNL1          208.0  0.0929 / -72.  0.9777 / 178.  1.0106 /  61.
   3LNL3        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                      FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
 3PNL1        3LNL3         N25            208.   388.1/ -88.    0.0/   0.     0.0/   0.

 --------------------------------------------------------------------------------------------

 3LNL4        VOLTAGE BASE LL:                208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    394.4 /  -88. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.528
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 555.783 +j 316.182 (PU)
                                  Z2: 555.783 +j 316.182 (PU)
                                  Z0: 709.940 +j 329.754 (PU)

           ASYM    RMS   INTERRUPTING AMPS
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
         394.4      394.4      394.4      394.4      394.4

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        0.0000 /    0.0     0.9875 /  175.8     1.0349 /   62.5

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
         394.4 / -87.8       0.0 /   0.0         0.0 /   0.0

 3LNL4        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  3PNL1          208.0  0.0783 / -72.  0.9776 / 178.  1.0112 /  61.
  3LNL4        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
3PNL1        3LNL4        N26             208.   394.4/ -88.     0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------

 3PNH1        VOLTAGE BASE LL:                480.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     1.001
        SEQUENCE EQUIVALENT IMPEDANCE Z1:   8.562 +j   8.273 (PU)
                                      Z2:   8.562 +j   8.273 (PU)
                                      Z0: INFINITE

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             0.0         0.0         0.0         0.0         0.0

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
            AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0 /   0.0         0.0 /   0.0         0.0 /   0.0

 3PNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---     ---PHASE B---     ---PHASE C---
  2PNH1          480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
              ---PHASE A---    ---PHASE B---    ---PHASE C---
  4PNL1          208.0  0.1028 / -73.  0.9751 / 179.  0.9934 /  61.
  4LNL3        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
4PNL1        4LNL3         N37            208.   405.2/ -89.     0.0/   0.     0.0/   0.

-------------------------------------------------------------------------------------------

 4LNL4        VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    418.5 /  -89. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.564
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 530.473 +j 314.182 (PU)
                              Z2: 530.473 +j 314.182 (PU)
                              Z0: 630.175 +j 324.829 (PU)

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              418.5       418.5       418.5       418.5       418.5

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.9828 /  177.1     1.0165 /   61.7

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---       ---PHASE C---
           418.5 / -89.4       0.0 /   0.0         0.0 /   0.0

 4LNL4        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
             FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---    ---PHASE B---    ---PHASE C---
  4PNL1          208.0  0.0732 / -74.  0.9749 / 179.  0.9940 /  61.
  4LNL4        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
4PNL1        4LNL4         N38            208.   418.5/ -89.     0.0/   0.     0.0/   0.

-------------------------------------------------------------------------------------------

 4LNL5        VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    430.4 /  -90. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.573
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 520.118 +j 310.833 (PU)
                              Z2: 520.118 +j 310.833 (PU)
                              Z0: 597.541 +j 316.585 (PU)
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
        1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
            430.4      430.4      430.4      430.4      430.4

         INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
             AT TIME =    0.5 CYCLES
         ---PHASE A---      ---PHASE B---      ---PHASE C---
         0.0000 /    0.0    0.9795 /  177.7    1.0090 /   61.3

         INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
             AT TIME =    0.5 CYCLES
         ---PHASE A---      ---PHASE B---      ---PHASE C---
          430.4 / -89.8       0.0 /   0.0        0.0 /   0.0

 4LNL5       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
           FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
              ---PHASE A---    ---PHASE B---    ---PHASE C---
  4PNL1         208.0  0.0466 / -74.  0.9748 / 179.  0.9946 /  61.
  4LNL5       ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                 FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
4PNL1       4LNL5        N39           208.   430.4/ -90.    0.0/   0.    0.0/   0.

----------------------------------------------------------------------------------------------

 4LNL6       VOLTAGE BASE LL:               208.0 (VOLTS)
         INI. SYM. RMS FAULT CURRENT:   424.7 /  -90. ( AMPS/DEG )
         THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
         THEVENIN IMPEDANCE X/R RATIO:     0.568
         SEQUENCE EQUIVALENT IMPEDANCE Z1: 525.000 +j 312.411 (PU)
                                Z2: 525.000 +j 312.411 (PU)
                                Z0: 612.926 +j 320.471 (PU)

          ASYM    RMS   INTERRUPTING AMPS
         1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
            424.7      424.7      424.7      424.7      424.7

         INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
             AT TIME =    0.5 CYCLES
         ---PHASE A---      ---PHASE B---      ---PHASE C---
         0.0000 /    0.0    0.9810 /  177.4    1.0126 /   61.5

         INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
             AT TIME =    0.5 CYCLES
         ---PHASE A---      ---PHASE B---      ---PHASE C---
          424.7 / -89.6       0.0 /   0.0        0.0 /   0.0

 4LNL6       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
           FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
              ---PHASE A---    ---PHASE B---    ---PHASE C---
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
                       FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                       BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
4PNL1       4LNL6       N40           208.   424.7/ -90.    0.0/   0.    0.0/   0.

-------------------------------------------------------------------------------------------


 4LNL7       VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    422.2 /  -90. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.566
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 527.219 +j 313.129 (PU)
                                 Z2: 527.219 +j 313.129 (PU)
                                 Z0: 619.919 +j 322.238 (PU)

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              422.2       422.2       422.2       422.2       422.2

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     0.9817 /  177.3     1.0142 /   61.6

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           422.2 / -89.5       0.0 /   0.0         0.0 /   0.0

 4LNL7       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---     ---PHASE B---     ---PHASE C---
  4PNL1          208.0  0.0650 / -74.  0.9749 / 179.  0.9942 /  61.
  4LNL7         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                        FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                       BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
4PNL1       4LNL7       N41           208.   422.2/ -90.    0.0/   0.    0.0/   0.

-------------------------------------------------------------------------------------------

 4LNL8       VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    427.3 /  -90. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.570
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 522.781 +j 311.694 (PU)
                                 Z2: 522.781 +j 311.694 (PU)
                                 Z0: 605.932 +j 318.705 (PU)

           ASYM    RMS   INTERRUPTING AMPS
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
4PNL1         4LNL9         N43            208.   441.4/ -90.     0.0/   0.     0.0/   0.

------------------------------------------------------------------------------------------

 4PNL1        VOLTAGE BASE LL:               208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    451.3 /  -91. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.589
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 503.254 +j 305.378 (PU)
                              Z2: 503.254 +j 305.378 (PU)
                              Z0: 544.393 +j 303.160 (PU)

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             451.3       451.3       451.3       451.3       451.3

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0000 /    0.0     0.9745 /  178.7     0.9957 /   60.6

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
           451.3 / -90.5        0.0 /   0.0         0.0 /   0.0

 4PNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT     AT TIME =     0.5 CYCLES
                ---PHASE A---    ---PHASE B---    ---PHASE C---
  4LNL1           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  BUS-0027         208.0  0.0604 / -89.  0.9738 /-180.  0.9740 /  60.
  4LNL2           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  4LNL3           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  4LNL4           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  4LNL5           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  4LNL6           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  4LNL7           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  4LNL8           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  4LNL9           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.
  4LNL10           208.0  0.0000 /   0.  0.9745 / 179.  0.9957 /  61.

  4PNL1        =============== INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ===============
                   FIRST BUS FROM FAULT     AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
4PNL1         4LNL1         N35            208.    0.0/   0.     0.0/   0.     0.0/   0.
BUS-0027       4PNL1         N34            208.   451.3/ -91.     0.0/   0.     0.0/   0.
4PNL1         4LNL2         N36            208.    0.0/   0.     0.0/   0.     0.0/   0.
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
4PNL1     4LNL5     N39      208.   0.0/  0.   0.0/  0.   0.0/  0.
4PNL1     4LNL6     N40      208.   0.0/  0.   0.0/  0.   0.0/  0.
4PNL1     4LNL7     N41      208.   0.0/  0.   0.0/  0.   0.0/  0.
4PNL1     4LNL8     N42      208.   0.0/  0.   0.0/  0.   0.0/  0.
4PNL1     4LNL9     N43      208.   0.0/  0.   0.0/  0.   0.0/  0.
4PNL1     4LNL10    N44      208.   0.0/  0.   0.0/  0.   0.0/  0.

------------------------------------------------------------------------------------------

4POL1     VOLTAGE BASE LL:            208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    452.0 /  -91. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.590
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 501.743 +j 305.177 (PU)
                                        Z2: 501.743 +j 305.177 (PU)
                                        Z0: 544.393 +j 303.160 (PU)

          ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
             452.0      452.0      452.0      452.0      452.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---       ---PHASE C---
          0.0000 /    0.0    0.9746 /  178.6    0.9964 /   60.6

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---       ---PHASE C---
           452.0 / -90.5       0.0 /   0.0         0.0 /   0.0

4POL1     ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
               ---PHASE A---    ---PHASE B---    ---PHASE C---
 BUS-0095      208.0  0.0605 / -89.  0.9739 /-180.  0.9746 /  60.
 4POL1      ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
BUS-0095    4POL1     O17       208.   452.0/ -91.    0.0/   0.     0.0/   0.

------------------------------------------------------------------------------------------

5LNH1     VOLTAGE BASE LL:            480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:     0.0 /  -75. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     1.001
          SEQUENCE EQUIVALENT IMPEDANCE Z1:   2.412 +j   3.603 (PU)
                                        Z2:   2.412 +j   3.603 (PU)
                                        Z0: INFINITE
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          1/2 CYCLES   2 CYCLES   3 CYCLES   5 CYCLES   8 CYCLES
              0.0        0.0        0.0        0.0        0.0

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
           0.0000 /    0.0    1.6898 / -180.0    1.6898 /  120.0

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
              0.0 /   0.0       0.0 /   0.0        0.0 /   0.0

 5LNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---    ---PHASE B---    ---PHASE C---
  1PBP1           480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  5LNH1        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PBP1       5LNH1        N29           480.    0.0/ -75.    0.0/   0.     0.0/   0.

 ----------------------------------------------------------------------------------------------

 5LNL1        VOLTAGE BASE LL:               208.0 (VOLTS)
           INI. SYM. RMS FAULT CURRENT:    365.6 /  -85. ( AMPS/DEG )
           THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
           THEVENIN IMPEDANCE X/R RATIO:     0.463
           SEQUENCE EQUIVALENT IMPEDANCE Z1: 593.546 +j 309.840 (PU)
                                    Z2: 593.546 +j 309.840 (PU)
                                    Z0: 828.953 +j 314.145 (PU)

            ASYM    RMS   INTERRUPTING AMPS
           1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              365.7       365.6       365.6       365.6       365.6

           INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
           0.0000 /    0.0    0.9921 /  174.1    1.0608 /   63.3

           INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                AT TIME =     0.5 CYCLES
           ---PHASE A---      ---PHASE B---      ---PHASE C---
            365.6 / -84.9       0.0 /   0.0        0.0 /   0.0

 5LNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---    ---PHASE B---    ---PHASE C---
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
                    FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
5PNL1       5LNL1        N47           208.   365.6/ -85.    0.0/   0.     0.0/   0.
---------------------------------------------------------------------------------------------

 5LNL2       VOLTAGE BASE LL:               208.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:    332.8 /  -84. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     0.446
        SEQUENCE EQUIVALENT IMPEDANCE Z1: 634.966 +j 323.236 (PU)
                              Z2: 634.966 +j 323.236 (PU)
                              Z0: INFINITE

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
           332.8       332.8       332.8       332.8       332.8

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
             AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        0.0000 /    0.0     1.0068 /  172.7     1.0782 /   64.5

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
             AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
         332.8 / -84.0       0.0 /   0.0        0.0 /   0.0

 5LNL2       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                 ---PHASE A---    ---PHASE B---    ---PHASE C---
  5PNL1          208.0  0.0968 / -68.  0.9902 / 175.  1.0499 /  63.
  5LNL2        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                    BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
5PNL1       5LNL2        N48           208.   332.8/ -84.    0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------

5LNL3       VOLTAGE BASE LL:               208.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:    338.0 /  -84. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     0.448
        SEQUENCE EQUIVALENT IMPEDANCE Z1: 627.866 +j 320.940 (PU)
                              Z2: 627.866 +j 320.940 (PU)
                              Z0: 937.114 +j 341.467 (PU)

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
           338.0       338.0       338.0       338.0       338.0
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
        AT TIME =     0.5 CYCLES
 ---PHASE A---     ---PHASE B---     ---PHASE C---
 0.0000 /    0.0    1.0044 /  172.9    1.0755 /   64.3

 INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
        AT TIME =     0.5 CYCLES
 ---PHASE A---     ---PHASE B---     ---PHASE C---
  338.0 / -84.2       0.0 /   0.0        0.0 /   0.0

5LNL3       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
             ---PHASE A---    ---PHASE B---    ---PHASE C---
 5PNL1        208.0  0.0829 / -69.  0.9903 / 175.  1.0512 /  63.
 5LNL3       ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
               BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-     -PHASE C-
5PNL1        5LNL3        N49           208.   338.0/ -84.     0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------

5LNL4       VOLTAGE BASE LL:               208.0 (VOLTS)
 INI. SYM. RMS FAULT CURRENT:    347.0 /  -84. ( AMPS/DEG )
 THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
 THEVENIN IMPEDANCE X/R RATIO:     0.453
 SEQUENCE EQUIVALENT IMPEDANCE Z1: 616.180 +j 317.160 (PU)
                              Z2: 616.180 +j 317.160 (PU)
                              Z0: 900.283 +j 332.163 (PU)

  ASYM    RMS   INTERRUPTING AMPS
 1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
    347.0       347.0       347.0       347.0       347.0

 INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
        AT TIME =     0.5 CYCLES
 ---PHASE A---     ---PHASE B---     ---PHASE C---
 0.0000 /    0.0    1.0003 /  173.3    1.0708 /   64.0

 INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
        AT TIME =     0.5 CYCLES
 ---PHASE A---     ---PHASE B---     ---PHASE C---
  347.0 / -84.4       0.0 /   0.0        0.0 /   0.0

5LNL4       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
          FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
             ---PHASE A---    ---PHASE B---    ---PHASE C---
 5PNL1        208.0  0.0590 / -69.  0.9904 / 175.  1.0534 /  63.
 5LNL4       ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
               FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
         INI. SYM. RMS FAULT CURRENT:    355.0 /  -85. ( AMPS/DEG )
         THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
         THEVENIN IMPEDANCE X/R RATIO:     0.457
         SEQUENCE EQUIVALENT IMPEDANCE Z1: 606.120 +j 313.906 (PU)
                                       Z2: 606.120 +j 313.906 (PU)
                                       Z0: 868.581 +j 324.155 (PU)

          ASYM    RMS   INTERRUPTING AMPS
         1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            355.0       355.0       355.0       355.0       355.0

         INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =     0.5 CYCLES
         ---PHASE A---      ---PHASE B---      ---PHASE C---
         0.0000 /    0.0     0.9967 /  173.6     1.0665 /   63.7

         INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =     0.5 CYCLES
         ---PHASE A---      ---PHASE B---      ---PHASE C---
          355.0 / -84.6       0.0 /   0.0        0.0 /   0.0

 5LNL5       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
           FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
              ---PHASE A---    ---PHASE B---    ---PHASE C---
  5PNL1          208.0  0.0375 / -69.  0.9905 / 174.  1.0555 /  63.
  5LNL5        ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1       5LNL5        N51           208.   355.0/ -85.     0.0/   0.     0.0/   0.

-----------------------------------------------------------------------------------------------

 5LNL6       VOLTAGE BASE LL:               208.0 (VOLTS)
         INI. SYM. RMS FAULT CURRENT:    342.6 /  -84. ( AMPS/DEG )
         THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
         THEVENIN IMPEDANCE X/R RATIO:     0.451
         SEQUENCE EQUIVALENT IMPEDANCE Z1: 621.801 +j 318.978 (PU)
                                       Z2: 621.801 +j 318.978 (PU)
                                       Z0: 917.999 +j 336.639 (PU)

          ASYM    RMS   INTERRUPTING AMPS
         1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            342.6       342.6       342.6       342.6       342.6

         INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =     0.5 CYCLES
         ---PHASE A---      ---PHASE B---      ---PHASE C---
         0.0000 /    0.0     1.0023 /  173.1     1.0731 /   64.1
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =     0.5 CYCLES
          ---PHASE A---     ---PHASE B---     ---PHASE C---
           342.6 / -84.3      0.0 /   0.0       0.0 /   0.0

 5LNL6       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
               ---PHASE A---    ---PHASE B---    ---PHASE C---
  5PNL1         208.0  0.0707 / -69.  0.9903 / 175.  1.0523 /  63.
  5LNL6        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1       5LNL6       N52          208.   342.6/ -84.    0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------

 5LNL7       VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    352.0 /  -85. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.456
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 609.819 +j 315.103 (PU)
                                        Z2: 609.819 +j 315.103 (PU)
                                        Z0: 880.236 +j 327.100 (PU)

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             352.0       352.0       352.0       352.0       352.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =     0.5 CYCLES
          ---PHASE A---     ---PHASE B---     ---PHASE C---
          0.0000 /    0.0     0.9981 /  173.5     1.0681 /   63.8

          INI.   RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =     0.5 CYCLES
          ---PHASE A---     ---PHASE B---     ---PHASE C---
           352.0 / -84.5      0.0 /   0.0       0.0 /   0.0

 5LNL7       ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
               ---PHASE A---    ---PHASE B---    ---PHASE C---
  5PNL1         208.0  0.0455 / -69.  0.9905 / 174.  1.0547 /  63.
  5LNL7        ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                  FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1       5LNL7       N53          208.   352.0/ -85.    0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------

 5LNL8       VOLTAGE BASE LL:              208.0 (VOLTS)
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     0.461
        SEQUENCE EQUIVALENT IMPEDANCE Z1: 597.836 +j 311.227 (PU)
                                      Z2: 597.836 +j 311.227 (PU)
                                      Z0: 842.473 +j 317.561 (PU)

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            362.0       362.0       362.0       362.0       362.0

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        0.0000 /    0.0     0.9937 /  173.9     1.0628 /   63.4

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
         362.0 / -84.8        0.0 /    0.0        0.0 /    0.0

 5LNL8        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
                FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     ---PHASE A---     ---PHASE B---     ---PHASE C---
  5PNL1              208.0  0.0189 / -69.  0.9906 / 174.  1.0572 /  63.
  5LNL8         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                         FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                         BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
5PNL1         5LNL8         N54            208.   362.0/ -85.     0.0/   0.     0.0/   0.

----------------------------------------------------------------------------------------------

 5PNL1        VOLTAGE BASE LL:               208.0 (VOLTS)
        INI. SYM. RMS FAULT CURRENT:    369.0 /  -85. ( AMPS/DEG )
        THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
        THEVENIN IMPEDANCE X/R RATIO:     0.465
        SEQUENCE EQUIVALENT IMPEDANCE Z1: 589.700 +j 308.596 (PU)
                                      Z2: 589.700 +j 308.596 (PU)
                                      Z0: 816.832 +j 311.083 (PU)

         ASYM    RMS   INTERRUPTING AMPS
        1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
            369.0       369.0       369.0       369.0       369.0

        INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
              AT TIME =     0.5 CYCLES
        ---PHASE A---       ---PHASE B---       ---PHASE C---
        0.0000 /    0.0     0.9907 /  174.2     1.0590 /   63.2

        INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
              AT TIME =     0.5 CYCLES
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
369.0 / -84.9      0.0 /   0.0       0.0 /   0.0

 5PNL1      ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
               ---PHASE A---    ---PHASE B---    ---PHASE C---
  5LNL1        208.0  0.0000 /   0.  0.9907 / 174.  1.0590 /  63.
  BUS-0029     208.0  0.2468 / -83.  0.9739 /-180.  0.9745 /  60.
  5LNL2        208.0  0.0000 /   0.  0.9907 / 174.  1.0590 /  63.
  5LNL3        208.0  0.0000 /   0.  0.9907 / 174.  1.0590 /  63.
  5LNL4        208.0  0.0000 /   0.  0.9907 / 174.  1.0590 /  63.
  5LNL5        208.0  0.0000 /   0.  0.9907 / 174.  1.0590 /  63.
  5LNL6        208.0  0.0000 /   0.  0.9907 / 174.  1.0590 /  63.
  5LNL7        208.0  0.0000 /   0.  0.9907 / 174.  1.0590 /  63.
  5LNL8        208.0  0.0000 /   0.  0.9907 / 174.  1.0590 /  63.
  5PNL1      ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
5PNL1       5LNL1       N47          208.    0.0/   0.     0.0/   0.     0.0/   0.
BUS-0029     5PNL1       N46          208.   369.0/ -85.     0.0/   0.     0.0/   0.
5PNL1       5LNL2       N48          208.    0.0/   0.     0.0/   0.     0.0/   0.
5PNL1       5LNL3       N49          208.    0.0/   0.     0.0/   0.     0.0/   0.

  5PNL1      ================  FIRST BUS FROSYSTEM BRANCH FLOWS ( AMPS ) ================

5PNL1       5LNL4       N50          208.    0.0/   0.     0.0/   0.     0.0/   0.
5PNL1       5LNL5       N51          208.    0.0/   0.     0.0/   0.     0.0/   0.
5PNL1       5LNL6       N52          208.    0.0/   0.     0.0/   0.     0.0/   0.
5PNL1       5LNL7       N53          208.    0.0/   0.     0.0/   0.     0.0/   0.
5PNL1       5LNL8       N54          208.    0.0/   0.     0.0/   0.     0.0/   0.

-------------------------------------------------------------------------------------------

 5POL1       VOLTAGE BASE LL:              208.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:    452.0 /  -91. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     0.590
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 501.743 +j 305.177 (PU)
                                        Z2: 501.743 +j 305.177 (PU)
                                        Z0: 544.393 +j 303.160 (PU)

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             452.0       452.0       452.0       452.0       452.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =    0.5 CYCLES
          ---PHASE A---     ---PHASE B---      ---PHASE C---
          0.0000 /    0.0     0.9746 /  178.6     0.9964 /   60.6
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
            ---PHASE A---      ---PHASE B---      ---PHASE C---
             452.0 / -90.5       0.0 /   0.0        0.0 /   0.0

 5POL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0097        208.0  0.0605 / -89.  0.9739 /-180.  0.9746 /  60.
  5POL1         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT     AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
BUS-0097      5POL1         O15            208.   452.0/ -91.     0.0/   0.     0.0/   0.

-------------------------------------------------------------------------------------------

 6LNH1        VOLTAGE BASE LL:               480.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
            THEVENIN IMPEDANCE X/R RATIO:     1.001
            SEQUENCE EQUIVALENT IMPEDANCE Z1:   2.412 +j   3.603 (PU)
                                         Z2:   2.412 +j   3.603 (PU)
                                         Z0: INFINITE

             ASYM    RMS   INTERRUPTING AMPS
            1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
                 0.0         0.0         0.0         0.0         0.0

            INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---      ---PHASE C---
            0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

            INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
                 AT TIME =     0.5 CYCLES
            ---PHASE A---      ---PHASE B---      ---PHASE C---
               0.0 /   0.0       0.0 /   0.0        0.0 /   0.0

 6LNH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---     ---PHASE B---     ---PHASE C---
  1PBP1           480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  6LNH1         ================ INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                     FIRST BUS FROM FAULT     AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-     -PHASE B-     -PHASE C-
1PBP1         6LNH1         N28            480.     0.0/ -75.     0.0/   0.     0.0/   0.

-------------------------------------------------------------------------------------------

 6LNL1        VOLTAGE BASE LL:               208.0 (VOLTS)
            INI. SYM. RMS FAULT CURRENT:     387.0 /  -86. ( AMPS/DEG )
            THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
          SEQUENCE EQUIVALENT IMPEDANCE Z1: 568.089 +j 307.791 (PU)
                              Z2: 568.089 +j 307.791 (PU)
                              Z0: 748.722 +j 309.103 (PU)

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
             387.0       387.0       387.0       387.0       387.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0    0.9854 /  175.1     1.0460 /   62.6

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
           387.0 / -86.1       0.0 /   0.0        0.0 /   0.0

 6LNL1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
            FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                ---PHASE A---     ---PHASE B---     ---PHASE C---
  BUS-0031        208.0  0.2070 / -84.  0.9739 /-180.  0.9744 /  60.
  6LNL1        =============== INI.    RMS   SYSTEM BRANCH FLOWS ( AMPS ) ===============
                   FIRST BUS FROM FAULT     AT TIME =     0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
BUS-0031      6LNL1         N32           208.   387.0/ -86.     0.0/   0.     0.0/   0.

---------------------------------------------------------------------------------------------
 6PNH1        VOLTAGE BASE LL:               480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     1.001
          SEQUENCE EQUIVALENT IMPEDANCE Z1:   9.569 +j   8.964 (PU)
                              Z2:   9.569 +j   8.964 (PU)
                              Z0: INFINITE

           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
               0.0         0.0         0.0         0.0         0.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0    1.6898 / -180.0     1.6898 /  120.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
             0.0 /   0.0       0.0 /   0.0        0.0 /   0.0
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
                  ---PHASE A---    ---PHASE B---    ---PHASE C---
  2PNH1           480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  6PNH1         ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
2PNH1        6PNH1        N56          480.    0.0/ -75.    0.0/   0.    0.0/   0.

-----------------------------------------------------------------------------------------

 6POH1        VOLTAGE BASE LL:              480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     1.001
          SEQUENCE EQUIVALENT IMPEDANCE Z1:   1.619 +j   3.389 (PU)
                                Z2:   1.619 +j   3.389 (PU)
                                Z0: INFINITE

          ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
               0.0         0.0         0.0         0.0         0.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
          0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---      ---PHASE B---      ---PHASE C---
             0.0 /   0.0        0.0 /   0.0        0.0 /   0.0

 6POH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
              FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                  ---PHASE A---    ---PHASE B---    ---PHASE C---
  1POH3           480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
  6POH1         ================ INI.   RMS   SYSTEM BRANCH FLOWS ( AMPS ) ================
                    FIRST BUS FROM FAULT    AT TIME =    0.5 CYCLES
                   BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-    -PHASE C-
1POH3        6POH1        O11          480.    0.0/ -75.    0.0/   0.    0.0/   0.

-----------------------------------------------------------------------------------------

 6PSH1        VOLTAGE BASE LL:              480.0 (VOLTS)
          INI. SYM. RMS FAULT CURRENT:      0.0 /  -75. ( AMPS/DEG )
          THEVENIN EQUIVALENT IMPEDANCE:  INFINITE
          THEVENIN IMPEDANCE X/R RATIO:     1.001
          SEQUENCE EQUIVALENT IMPEDANCE Z1:   6.441 +j   6.750 (PU)
                                Z2:   6.441 +j   6.750 (PU)
                                Z0: INFINITE
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

```
           ASYM    RMS   INTERRUPTING AMPS
          1/2 CYCLES    2 CYCLES    3 CYCLES    5 CYCLES    8 CYCLES
              0.0         0.0         0.0         0.0         0.0

          INI. SYM. RMS FAULTED BUS VOLTAGES ( PU / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
          0.0000 /    0.0     1.6898 / -180.0     1.6898 /  120.0

          INI.    RMS   FAULTED CURRENT ( AMPS / DEG )
               AT TIME =     0.5 CYCLES
          ---PHASE A---       ---PHASE B---       ---PHASE C---
             0.0 /   0.0        0.0 /   0.0         0.0 /   0.0

 6PSH1        ==== INI. SYM. RMS SYSTEM BUS VOLTAGES ( PU / DEG ) =======
                FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                    ---PHASE A---     ---PHASE B---     ---PHASE C---
   BUS-0114        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   BUS-0202        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   BUS-0203        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   BUS-0204        480.0  0.0000 /   0.  1.6898 /-180.  1.6898 / 120.
   6PSH1        ================ INI.    RMS    SYSTEM BRANCH FLOWS ( AMPS ) ================
                      FIRST BUS FROM FAULT    AT TIME =     0.5 CYCLES
                     BRANCH NAME   VBASE LL  -PHASE A-    -PHASE B-     -PHASE C-
BUS-0114     6PSH1         S3            480.    0.0/ -73.     0.0/   0.      0.0/   0.
6PSH1        BUS-0202      S5            480.    0.0/   0.     0.0/   0.      0.0/   0.
6PSH1        BUS-0203      S6            480.    0.0/   0.     0.0/   0.      0.0/   0.
6PSH1        BUS-0204      S7            480.    0.0/   0.     0.0/   0.      0.0/   0.

-------------------------------------------------------------------------------------------


***************** F A U L T    A N A L Y S I S    S U M M A R Y ***************
------------------------------------------------------------------------------
------------------------------------------------------------------------------
 BUS NAME          VOLTAGE          AVAILABLE FAULT CURRENT
                 L-L         3 PHASE      X/R LINE/GRND    X/R

 1LNH1              480.        37952.6     2.0        0.00       1.0
 1LNL1              208.          1357.0     0.8   1214.57      0.6
 1LNL2              208.           325.3     0.4     264.67      0.3
 1LVSG1              480.            0.0     0.0
*** NOTICE ***  ABOVE DUTY IS LESS THAN 0.5 AMPS

 1PBP1              480.        33576.9      2.5      0.00       1.0

 1PEH1              480.        31185.2      1.7      0.00       1.0
 1PNH1              480.        45573.4      4.5      0.00       1.0
 1PNH2              480.        38791.1      2.7      0.00       1.0
 1PNH3              480.        37048.0      2.5      0.00       1.0
```

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

****************** F A U L T   A N A L Y S I S   S U M M A R Y ****************

BUS NAME	VOLTAGE L-L	AVAILABLE FAULT CURRENT 3 PHASE	X/R	LINE/GRND	X/R
1POH1	480.	39185.3	3.6	0.00	1.0
1POH2	480.	15683.9	0.8	0.00	1.0
1POH3	480.	36131.6	3.1	0.00	1.0
1PSH1	480.	12091.6	1.0	0.00	1.0
1SWBDG1	480.	0.0	0.0		

*** NOTICE *** ABOVE DUTY IS LESS THAN 0.5 AMPS

BUS NAME	VOLTAGE L-L	3 PHASE	X/R	LINE/GRND	X/R
1USSHV1	480.	54283.3	11.0	0.00	1.0
2LNH1	480.	19663.0	0.8	0.00	1.0
2LNL1	208.	451.0	0.6	440.55	0.6
2PNH1	480.	31858.9	2.3	0.00	1.0
3LNH1	480.	27063.5	1.5	0.00	1.0
3LNL1	208.	442.8	0.6	423.42	0.5
3LNL2	208.	414.7	0.6	381.61	0.5
3LNL3	208.	419.2	0.6	388.11	0.5
3LNL4	208.	423.5	0.6	394.37	0.5
3PNH1	480.	9856.1	1.0	0.00	1.0
3PNL1	208.	445.7	0.6	427.89	0.6
4LNH1	480.	27063.5	1.5	0.00	1.0
4LNL1	208.	457.1	0.6	446.55	0.6
4LNL10	208.	452.0	0.6	438.43	0.6
4LNL2	208.	428.5	0.6	402.23	0.6
4LNL3	208.	430.4	0.6	405.17	0.6
4LNL4	208.	439.2	0.6	418.50	0.6
4LNL5	208.	446.9	0.6	430.42	0.6
4LNL6	208.	443.3	0.6	424.72	0.6
4LNL7	208.	441.6	0.6	422.17	0.6
4LNL8	208.	444.9	0.6	427.29	0.6
4LNL9	208.	453.8	0.6	441.35	0.6
4PNL1	208.	460.0	0.6	451.30	0.6
4POL1	208.	461.1	0.6	452.00	0.6
5LNH1	480.	27063.5	1.5	0.00	1.0
5LNL1	208.	404.5	0.5	365.65	0.5
5LNL2	208.	380.1	0.5	332.84	0.4
5LNL3	208.	384.0	0.5	338.05	0.4
5LNL4	208.	390.8	0.5	346.97	0.5
5LNL5	208.	396.7	0.5	355.03	0.5
5LNL6	208.	387.5	0.5	342.62	0.5

V. ELECTRICAL DEPTH

F) SKM ANALYSIS

SHORT CIRCUIT ANALYSIS(CONT'D)

*************** F A U L T   A N A L Y S I S   S U M M A R Y ***************

BUS NAME	VOLTAGE L-L	AVAILABLE FAULT CURRENT 3 PHASE	X/R	LINE/GRND	X/R
5LNL8	208.	401.8	0.5	361.96	0.5
5PNL1	208.	406.9	0.5	369.02	0.5
5POL1	208.	461.1	0.6	452.00	0.6
6LNH1	480.	27063.5	1.5	0.00	1.0
6LNL1	208.	419.1	0.5	386.95	0.5
6PNH1	480.	8950.1	0.9	0.00	1.0
6POH1	480.	31242.8	2.1	0.00	1.0
6PSH1	480.	12577.4	1.0	0.00	1.0

********************** FAULT ANALYSIS REPORT COMPLETED **********************

V. ELECTRICAL DEPTH

G) PROTECTIVE DEVICE COORDINATION STUDY

ASSUMPTIONS

There were three major assumptions which were necessary to conduct this short circuit analysis by hand. The available short circuit current at the service entrance is very difficult to find from the utlility. When design documents were collected for this building , the project had not commenced construction. A power utility company typically does not assist electrical engineers with this information until they know the project will be constructed. The capacity of the utility was assumed at a value of 500 MVA with a reactance to resistance ratio of 12. The ratio for the main transformer in the example was used because this building also has a 2500 KVA rated main transformer as well.

Another assumption was made involving the bus of substation '1USSHV1'. The building's main transformer is integral to this substation. Therefore, a secondary feeder is replaced by low impedance bus. The impedance caused by this bus is negligible due to the fact that it is such a short run. The third assumption was that every conductor is lined with THHN insulation and was placed in steel conduit for simplicity.

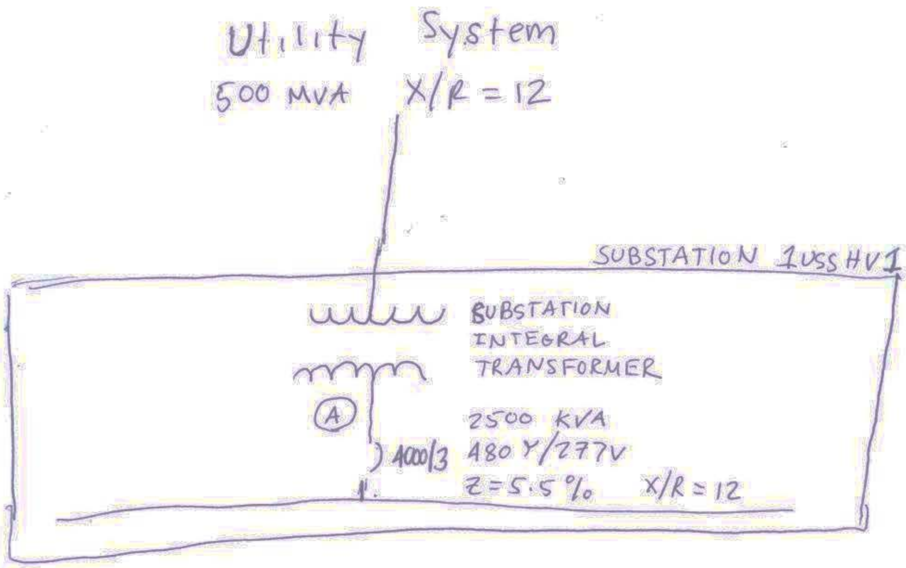
RESULTS

POINT	LOCATION	AVAILABLE FAULT CURRENT (AMPS)	STANDARD BREAKER SETTING (AMPS)
A	SUBSTATION '1USSHV1'	50,999	65,000
B	SWITCHBOARD '1PNH1'	42,437	50,000
C	XFMR '1T1' (SECONDARY WINDINGS)	1868	10,000
D	PANEL '1LNL1'	1820	10,000

V. ELECTRICAL DEPTH

G) PROTECTIVE DEVICE COORDINATION STUDY

SHORT CIRCUIT CALCULATIONS



Utility Impedance

$$Z_{UTIL} = \frac{(KV)^2 \times 10^6}{KVA_{UTIL}} = \frac{(0.480\ KV)^2 \times 10^6}{500,000\ KVA} = 0.461\ m\Omega$$

Resitance & Reactance Components

$$R_{UTIL} = Z_{UTIL} \cos\left[\tan^{-1}\left(\tfrac{X}{R}\right)\right] = 0.461 \cos\left[\tan^{-1}(12)\right] = 0.038\ m\Omega$$

$$X_{UTIL} = Z_{UTIL} \sin\left[\tan^{-1}\left(\tfrac{X}{R}\right)\right] = 0.461 \sin\left[\tan^{-1}(12)\right] = 0.459\ m\Omega$$

$$R_{XFMR} = \frac{KV^2 \times \%Z \times 10^4 \times \cos\left[\tan^{-1}\left(\tfrac{X}{R}\right)\right]}{KVA_{XFMR}} = \frac{(0.480\ KV)^2 \times 5.5 \times 10^4 \times \cos\left[\tan^{-1}(12)\right]}{2500\ KVA}$$

$$R_{XFMR} = 0.421\ m\Omega$$

$$X_{XFMR} = \frac{(KV)^2 \times \%Z \times 10^4 \times \sin\left[\tan^{-1}\left(\tfrac{X}{R}\right)\right]}{KVA_{XFMR}} = \frac{(0.480)^2 \times 5.5 \times 10^4 \times \sin\left[\tan^{-1}(12)\right]}{2500\ KVA}$$

$$X_{XFMR} = 5.051\ m\Omega$$

IMPEDANCE AT SUBSTATION "1USS HV1" (A)

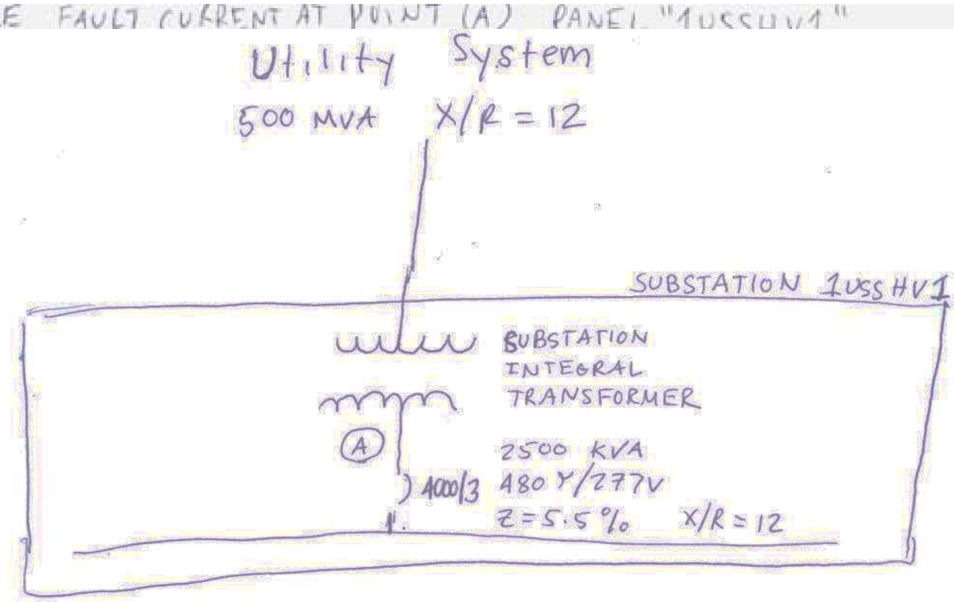
$$Z_{TOTAL} = Z_{UTIL} + Z_{XFMR} = (0.38 + j0.459) + (4.21 + j5.051) = 0.459 + j5.51\ m\Omega$$

V. ELECTRICAL DEPTH

G) PROTECTIVE DEVICE COORDINATION STUDY

SHORT CIRCUIT CALCULATION (CONT'D)

AVAILABLE FAULT CURRENT AT POINT (A) PANEL "1USSHV1"



Utility Impedance

$$Z_{UTIL} = \frac{(KV)^2 \times 10^6}{KVA_{UTIL}} = \frac{(0.480\ KV)^2 \times 10^6}{500,000\ KVA} = 0.461\ m\Omega$$

Resitance & Reactance Components

$$R_{UTIL} = Z_{UTIL} \cos\left[\tan^{-1}\left(\frac{X}{R}\right)\right] = 0.461 \cos\left[\tan^{-1}(12)\right] = 0.038\ m\Omega$$

$$X_{UTIL} = Z_{UTIL} \sin\left[\tan^{-1}\left(\frac{X}{R}\right)\right] = 0.461 \sin\left[\tan^{-1}(12)\right] = 0.459\ m\Omega$$

$$R_{XFMR} = \frac{kv^2 \times \%Z \times 10^4 \times \cos\left[\tan^{-1}\left(\frac{X}{R}\right)\right]}{KVA_{XFMR}} = \frac{(0.480\ Kv)^2 \times 5.5 \times 10^4 \times \cos[\tan^{-1}(12)]}{2500\ KVA}$$

$$R_{XFMR} = 0.421\ m\Omega$$

$$X_{XFMR} = \frac{(Kv)^2 \times \%Z \times 10^4 \times \sin\left[\tan^{-1}\left(\frac{X}{R}\right)\right]}{KVA_{XFMR}} = \frac{(0.480)^2 \times 5.5 \times 10^4 \times \sin[\tan^{-1}(12)]}{2500\ KVA}$$

$$X_{XFMR} = 5.051\ m\Omega$$

IMPEDANCE AT SUBSTATION "1USSHV1" (A)

$$Z_{TOTAL} = Z_{UTIL} + Z_{XFMR} = (0.38 + j0.459) + (4.21 + j5.051) = 0.459 + j5.51\ m\Omega$$

V. ELECTRICAL DEPTH

G) PROTECTIVE DEVICE COORDINATION STUDY

SHORT CIRCUIT CALCULATION (CONT'D)

FEEDER "N2 IMPEDANCE

Table 2 → $R = 3.33$ (COPPER CONDUCT., STEEL CONDUIT, #350 KCMIL)
$X_L = 4.07$

$$R_{N2} = \frac{L}{100} \times R \times \frac{1}{\#\text{ of sets}} = \frac{44.5'}{100} \times 3.33 \times \frac{1}{2\text{ sets}}$$

$$R_{N2} = 0.741\,m\Omega$$

$$X_{N2} = \frac{L}{100} \times X_L \times \frac{1}{\#\text{ of sets}} = \frac{44.5'}{100} \times 4.07 \times \frac{1}{2\text{ sets}}$$

$$X_{N2} = 0.906\,m\Omega$$

Impedance at Distribution Panel "1PNH1" (B)

$$Z_{TOTAL} = Z_{1USSHV1} + Z_{N2}$$

$$Z_{TOTAL} = (0.459 + j\,5.51) + (0.741 + j\,0.906)$$

$$Z_{TOTAL} = 1.2 + j\,6.416$$

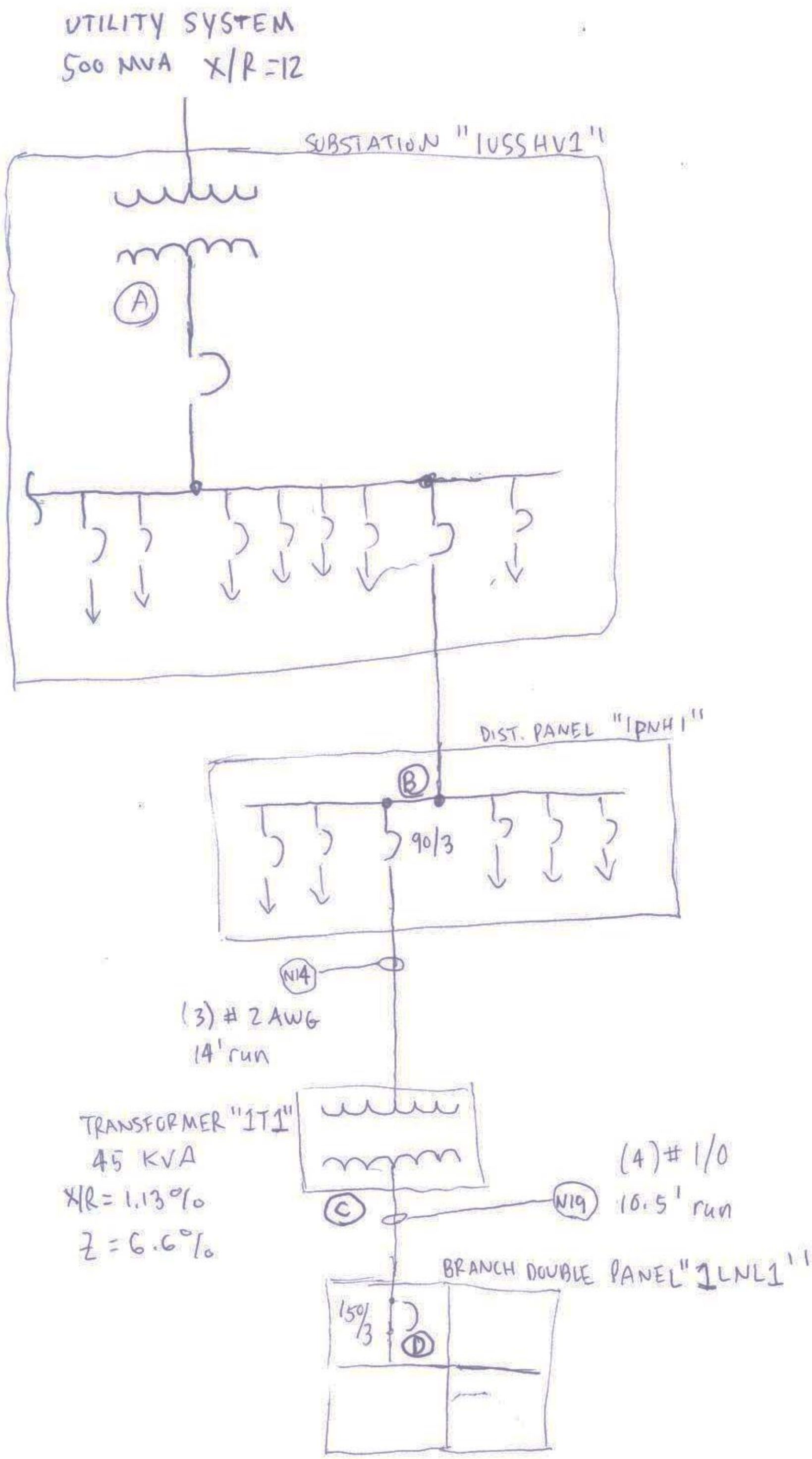
AVAILABLE FAULT CURRENT AT DIST. PANEL "1PNH1" (B)

$$I_{SC} = \frac{277 \times 1000}{\sqrt{(1.2)^2 + (6.416)^2}} = 42,437\,A$$

V. ELECTRICAL DEPTH

G) PROTECTIVE DEVICE COORDINATION STUDY

SHORT CIRCUIT CALCULATION (CONT'D)



V. ELECTRICAL DEPTH

G) PROTECTIVE DEVICE COORDINATION STUDY

SHORT CIRCUIT CALCULATION (CONT'D)

FEEDER "N14" IMPEDANCE (Table 2 → R = 16.4, X_L = 4.2; copper conduct. steel conduit #2 AWG)

$$R_{N14} = \frac{14'}{100} \times 16.4 \times \frac{1}{1\ set} = 2.296\ m\Omega$$

$$X_{N14} = \frac{14'}{100} \times 4.2 \times \frac{1}{1\ set} = 0.588\ m\Omega$$

Impedance at Winding of XFMR "1T1"

$$Z_{TOTAL} = Z_{1PNH1} + Z_{N14}$$

$$Z_{TOTAL} = (1.2 + j\,6.416) + (2.296 + j\,0.588)$$

$$Z_{TOTAL} = 3.496 + j\,7.004$$

IMPEDANCE REFLECTION THROUGH WINDINGS OF "1T1" (Primary)

$$Z_{sec} = \frac{1}{\alpha^2} \times Z_{PRI}$$

$$\alpha = \frac{V_{PRI}}{V_{sec}} = \frac{480}{208} = 2.308 \qquad \frac{1}{\alpha^2} = 0.188$$

$$Z_{sec} = \frac{1}{\alpha^2} Z_{pri} = (0.188)(3.496 + j\,7.004)$$

$$Z_{sec} = 0.657 + j\,1.317$$

V. ELECTRICAL DEPTH

G) PROTECTIVE DEVICE COORDINATION STUDY

SHORT CIRCUIT CALCULATION (CONT'D)

IMPEDANCE OF STEP DOWN XFMR "1T1"

Table 4 → 45 kVA $X/R = 1.13\%$ $Z = 6.6\%$

$$R_{1T1} = \frac{(0.208)^2 \times 6.6 \times 10^4 \times \cos[\tan^{-1}(1.13)]}{45}$$

$R_{1T1} = 42.052 \ m\Omega$

$$X_{1T1} = \frac{(0.208)^2 \times 6.6 \times 10^4 \times \sin[\tan^{-1}(1.13)]}{45 \text{ kVA}}$$

$X_{1T1} = 47.519 \ m\Omega$

IMPEDANCE AT SECONDARY WINDINGS OF XFMR "1T1" (C)

$Z_{TOTAL} = Z_{BEK} + Z_{1T1}$

$Z_{TOTAL} = (0.657 + j1.317) + (42.052 + j47.519)$

$Z_{TOTAL} = (42.709 + j48.836)$

AVAILABLE FAULT CURRENT AT SECONDARY WINDINGS OF "1T1" (C)

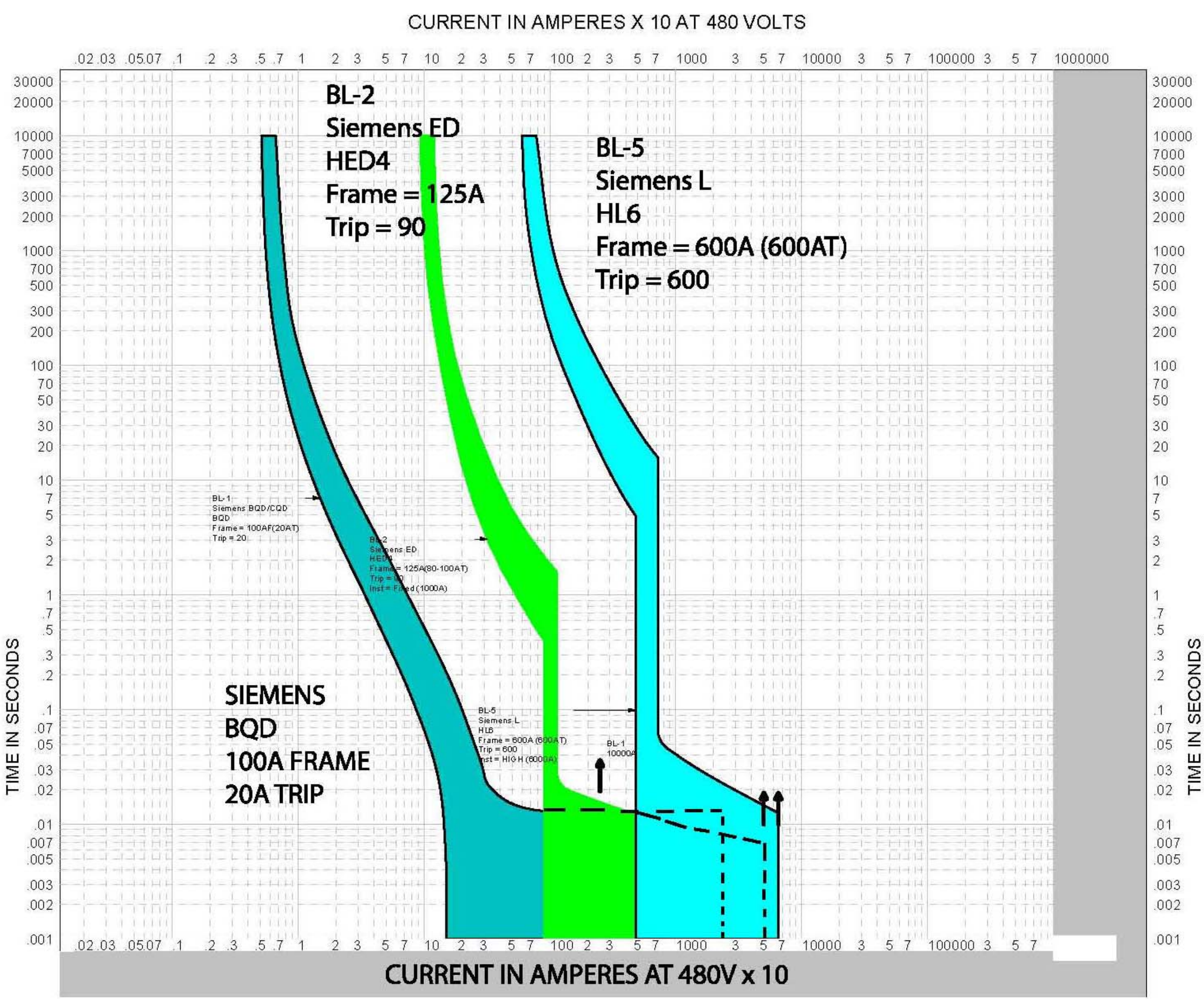
$$I_{SC} = \frac{120V \times 1000}{\sqrt{(42.709)^2 + (48.836)^2}} = 1868 \text{ A}$$

V. ELECTRICAL DEPTH

G) PROTECTIVE DEVICE COORDINATION STUDY

PROTECTIVE DEVICE OVERLAY

The overlay turned out to be a success for the most part. The 20A breaker trips at lower currents before the 90A breaker upstream. This occurs for the 90A breaker and the 600A as well. There is no overlap either for any of the overload areas. However in the short circuit region the 20A curve crosses the 90A curve slightly around 15000A. This is not a problem though because the 20A branch breaker would never see this amount of short circuit current because there is not enough available that far downstream. The breakers have at or more than the specified short circuit interrupting rating calculated in this section.



VI. BREADTHS

A.) INTRODUCTION

This auditorium space will generally be used as a teaching environment. Therefore the architecture of this space should facilitate a positive learning environment. For an auditorium, the ceiling height appeared to be rather low in comparison to other auditoriums. Research was conducted to determine whether ceiling height had an effect on a student's ability to learn.

Cognitive skills are basic abilities we use to learn, study, and think. There are many mental processes which humans use. These processes allow us to analyze images from our vision, remembering information we have learned in the past, and to keep our concentration on tasks at hand. If the architecture can provide an environment that supports cognitive skill strength and efficiency, then students will have an easier time learning (Cognitive Definition)

The University of Minnesota conducted research on human information processing. There are five dimensions of long term memory in a human being: item-specific processing, relational processing, strategic processing, affective processing, and empirical processing. The two relative processes for this thesis research were the item-specific and relational types. The definition of these two processes are taken from *The Architecture of Human Information Processing: Empirical Evidence*, " Item-specific information results from processing characterized by the encoding of distinctive information unique to each separate input event, whereas relational information is generated by processing involving the abstraction of common features shared by the elements or events present at input. The results of this empirical investigation revealed that relational processing had a direct effect on cognitive skill performance while item-specific processing only had a minor effect (Taylor pp. 347-359).

More research was conducted at the University of Minnesota to determine whether ceiling height can prime concepts that in turn influence how people process information. The results showed that a taller ceiling height induced relational processing more than item-specific. So increasing the ceiling height is beneficial because it stimulates relational processing, which in turn will help students' cognitive skill strength (Meyers-Levy).

The proposed redesign will be to raise the auditorium's gypsum wallboard ceiling 4' higher than the original design to help facilitate a better learning environment. However, raising this ceiling could bring about changes to the HVAC system of this building. The ceiling could not simply change heights. It is in close proximity to the roof joists. The whole roof and brick on CMU exterior walls had to be raised along with it. The roof area did not change, but the space has more exterior wall area, which in turn causes a greater cooling load.

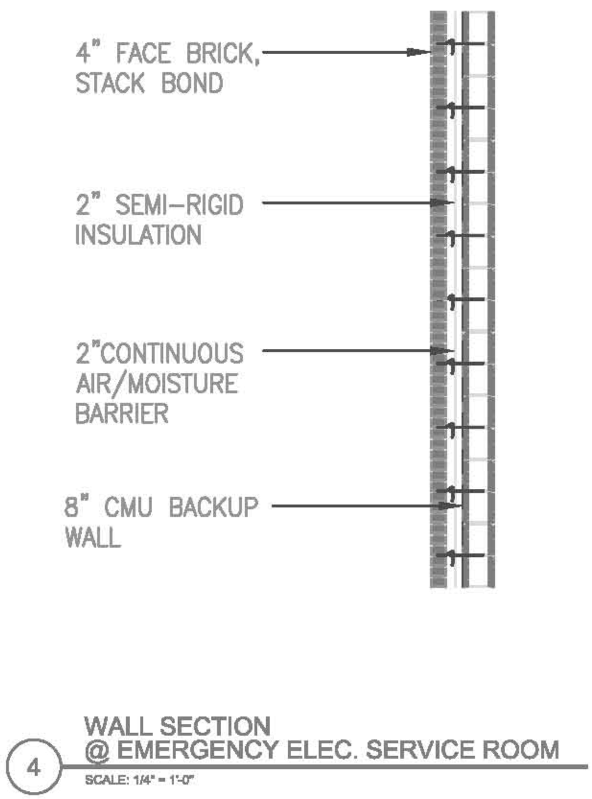
VI. BREADTHS

B.) HVAC BREADTH

INTRODUCTION

In order to determine the extra load the HVAC system has to take care of, the solar air temperature. The solar air temperature calculation incorporates the effects of solar radiation, thermal radiation, and convection into one calculation. The solar air temperature is an effective temperature that would give a similar heat transfer that would occur due to conduction, convection, and radiation. It estimates these three processes into one single heat transfer It is a more accurate calculation than using a U value and area. It is an effective estimate because this space does not have surfaces with large conductance values such as glass (McQuiston, 256).

The auditorium wall is a brick on CMU envelope. There are no windows anywhere along this wall. The wall consists of 1 wythe of brick, 2 inches of insultation, a 2"air gap, and then 8" CMU. Finally there is a varying air gap between the CMU and gypsum wall board. However this gypsum wall board is at ambient temperature because it is not adjacent to the wall construction.



<u>FIG. H-1</u>
AUDITORIUM WALL SECTION

VI. BREADTHS

B.) HVAC BREADTH

CALCULATIONS

The first step was to calculate the new loads which were caused from the added exterior surface area. Most of the wall construction type is CMU with a brick veneer. The equivalent wall resistance had to be found for this heat transfer through the envelope. This wall is a series equivalent heat transfer because the layers are stacked vertically against each other. The resistance values were referenced from the Heating Ventilationg, and Air Conditioning Text.

Next the solar air temperature had to be calculated. A program called BinMaker organizes weather data from TMY2. TMY2(Typical Meteorological Year) was a study conducted in 229 locations in the United States between 1961 to 1990. This data is used to describe the local solar climate of a place. Weather data was collected every hour for every day of the week. The town of Union, NJ, this building's location, is relatively close to New York City. New York City was a part of this weather analysis and its weather data was used to find this solar air temperature. The average summer wind speed was assumed to be 7.5 m.p.h. Also the hottest month was assumed to be August even though July could have been used as well. By using Equation 8-63 in Heating Ventilating and Air Conditioning was solved by creating a chart of this data finding the largest solar air temperature depending on the factors of dry bulb temperature and. The thermal radiation correction term is assumed to be 0 since this is a vertical surface. Brlow are the calculations to find this added load:

VI. BREADTHS

B.) HVAC BREADTH

CALCULATIONS (CONT'D)

Find R Values

4" (nominal) thick brick

Table 5-1 a p 124 → $k_{BRICK} = 6.2 \frac{Btu-in}{hr-ft^2-F}$

$$C = K \times \frac{1}{depth} = 6.2 \frac{Btu-in}{hr-ft^2-F} \times \frac{1}{3.625\ in} = 1.71 \frac{Btu}{hr-ft^2-F}$$

$$R_{BRICK} = \frac{1}{C_{BRICK}} = \frac{1}{1.710} = 0.585 \frac{hr-ft^2-F}{Btu}$$

Air gap 2"

Table 5-3a p 134 → vertical surface horizontal heat transfer
Mean T = 50°F , Temp Diff = 10°F,
$E_B = 0.82$

Interpolate between 1.5" + 3.5" air → $R_{air} = 1.015 \frac{hr-ft^2-F}{Btu}$

2" rigid insulation

Table 5-1a p 122 → $C_{INSUL} = 0.091 \frac{Btu}{hr-ft^2-F}$

$$R_{INSUL} = \frac{1}{C_{INSUL}} = \frac{1}{0.091} = R_{INSUL} = 10.989 \frac{hr-ft^2-F}{Btu}$$

8" (nominal) CMU

Table 5-1a p 124 → $C_{CMU} = 0.965 \frac{Btu}{hr-ft^2-F}$

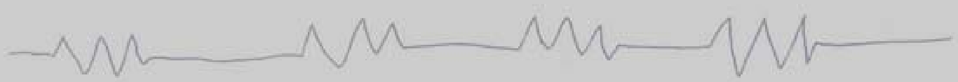
$$R_{CMU} = \frac{1}{C_{CMU}} = \frac{1}{0.965} = 1.036 \frac{hr-ft^2-F}{Btu}$$

VI. BREADTHS

B.) HVAC BREADTH

CALCULATIONS (CONT'D)

Find Equivalent Resistance



$R_{BRICK} = 0.585$ $R_{AIR} = 1.015$ $R_{INSUL} = 10.989$ $R_{CMU} = 1.036$

$$R_{equiv} = \Sigma R = 13.625 \ \frac{hr\text{-}ft^2\text{-}F}{Btu}$$

Calculate Solar Air Temperature

$$t_e = t_o + \alpha G_T / h_o - \epsilon \delta R / h_o$$

↳ vertical surface being calculated → approximate this term as 0°F

h_o → p 131 Table 5-2a → Wind $7\frac{1}{2}$ mph (summer)

$$h_o = 4.0 \ \frac{Btu}{hr\text{-}ft^2\text{-}F}$$

α → red brick (purdue) Table 71 p 183 → $\alpha = 0.63$

G_T → reference chart of G_T per hour for the entire month of August (hottest month)

$G_{T,max}$ =

$t_{e,max}$ occurs at 1:00 P.M. on August 14th

$t_{e,max} = 126.54°F$

VI. BREADTHS

B.) HVAC BREADTH

CALCULATIONS (CONT'D)

Added load ($\dot{Q}$) from wall height increase

$$\dot{Q} = (126.54 - 72)^{\circ}F \cdot 1804\ ft^2 \times \frac{1}{13.625\ \frac{hr\text{-}ft^2\text{-}F}{Btu}}$$

↑ added wall exterior area

$$\dot{Q} = 7221\ \frac{Btu}{hr} \quad \text{added load}$$

Rest of surface area assume same R value

Original Design Area ≈ 13,491 SF

$$\dot{Q} = (126.54 - 72^{\circ}\text{ set point})\ 13,491 \cdot \frac{1}{13.625\ \frac{hr\text{-}ft^2\text{-}F}{Btu}}$$

$$\dot{Q} = 54,000\ Btu/hr$$

$$\frac{\dot{Q}_{additional}}{\dot{Q}_{additional} + \dot{Q}_{existing}} = \frac{7221}{7221 + 54,000}$$

12% increase in AHU cfm & local CFM 4 Btu

VI. BREADTHS

B.) HVAC BREADTH

CALCULATIONS (CONT'D)

Check if fan has sufficient capacity

8600 cfm supply × 1.12 = 9632 cfm

4 fans @ 2500 cfm a piece = 1000 cfm

1000 cfm > 9632 cfm

Fan can handle load

VI. BREADTHS

B.) HVAC BREADTH

CALCULATIONS (CONT'D)

BR → Brick
CW → Curtainwall
M1/M2 → Aluminum Composite Panel
OGWB → Outdoor Gypsum Wallboard
RF → EPDM Rubber
GRF → Green Roof

APPROXIMATE EXTERIOR SURFACE AREA OF BUILDING

TOTAL BR	≈ 10,684 SF
TOTAL CW	≈ 42,068 SF
TOTAL M1/M2	≈ 15,258 SF
TOTAL RF	≈ 26,191 SF
TOTAL GRF	≈ 1311 SF
TOTAL OGWB	≈ 9428 SF
TOTAL EXPOSED AREA	**≈ 104,940 SF**

Percentage

$$\frac{1804\ SF}{104{,}940\ SF} = 0.011$$

The energy bill will increase approximately 1.72 % per year. However this is most likely less since almost half the building's surface area is composed of curtain wall.

VI. BREADTHS

B.) HVAC BREADTH

CONCLUSION

The added load from the extra exterior surface area does not change the AHU-2 which just serves the auditorium. This will not affect energy costs too much as shown above. The fans are able to handle the existing load by an engineering check and do not require to be resized. So raising the roof and ceiling inside the auditorium will not cause major HVAC resizing of equipment.

VI. BREADTHS

C.) STRUCTURAL BREADTH

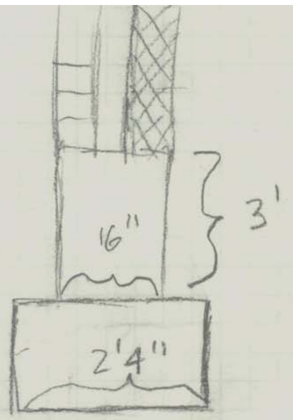
INTRODUCTION

This structural depth arose from the ceiling height changes because the auditorium's ceiling itself could not be moved. The roof joists were too close to the ceiling at the higher points of it as it staggered upward.that the roof had to be extended upward. The auditorium is one floor above the slab on grade. The auditorium has no floors above it anywhere, which made this option more feasible from the start. The four foot extension of the columns was not a problem at all for buckling., however, the auditorium has CMU walls with a brick veneer all resting on top of a strip foundation. This added weight caused potential for the foundation to be resized. The specifications call out for 4,000 psi concrete, but 2500 psi was used as a conservative estimate for a shallow footing. Below are the calculations to prove that the foundation supporting the auditorium walls does not need to be resized.

VI. BREADTHS

C.) STRUCTURAL BREADTH

CALCULATIONS



8" CMU → 55 psf (40.5' high) = 2.23 k/ft

4" brick → 40 psf (40.5' high) = 1.62 k/ft

q → 2500 psi → conservative estimate for shallow footing

$150 \text{ lb/ft}^3 \times \frac{16''}{12} \times \frac{36''}{12} = 0.6 \text{ k/ft}$

$q \geq \frac{P}{A} \qquad 2.5 \text{ ksf} \geq \frac{(4.45 \text{ k/ft})(1')}{(B)(1')}$

$B \geq 1.78'$

use 2'4" to check if resizing is necessary

$P_u = 1.4 P_D$ max dead load

No live load

$P_u = 1.4(4.45 \text{ k/ft}) = 6.23 \text{ k/ft}$

VI. BREADTHS

C.) STRUCTURAL BREADTH

CALCULATIONS(CONT'D)

VI BREADTHS
1) STRUCTURAL

11

$$q = \frac{P}{A} = \frac{(6.23\ k/ft)(1')}{(2.33')(1')} = 2.67\ ksf$$

Wide Beam Shear

$$\phi V_c = \phi 2 \sqrt{f'_c}\, bd$$

$$\phi V_c = 0.75(2)\sqrt{2500}\,(12'')\, d$$

$$\phi V_c = 900\, d$$

$$V_u = 2.67\ ksf\,(1')\left(2.\bar{3}' - \frac{8''}{12''}\right)$$

$$V_u = 4.5\ k$$

$$V_u = \phi V_n$$

$$4500\ lb = 900 d \qquad d = 5''$$

#5's using in plans

$$h = d + 3'' + 0.5 d_b$$

$$h = 5'' + 3'' + 0.5(0.625)$$

$$h = 8.3125''$$ → they have 1' depth for F2410 continuous footing

VI. BREADTHS

C.) STRUCTURAL BREADTH

CALCULATIONS(CONT'D)

John Mulhern | V BREADTHS A) STRUCTURAL | (1)

use $h = 12''$

$$d = 12'' - 3'' - \overset{0.5\,d_b}{0.3125} = 8.6875''$$

$$l = \frac{2.33' - 8''\left(\frac{1'}{12''}\right)}{2}$$

$$l = 0.8\bar{3}\ ft$$

$$M_u = \frac{q\,l^2}{2} = \frac{(2.6\ ksf)(0.8\bar{3})^2}{2}$$

$$M_u = 0.9\ 'k$$

Rebar Size

$$a = \frac{A_s f_y}{0.85\,f'_c\,b} = \frac{A_s\,(60\ ksi)}{0.85\,(2.5\ ksi)(12)}$$

$$a = 2.35\,A_s$$

$$M_u = \varphi M_n = \varphi A_s f_y\left(d - \frac{a}{2}\right)$$

$$(0.9\ 'k)\left(\frac{12\ in}{1\ ft}\right) = 0.9\,A_s(60\ ksi)\left(8.6875 - \frac{2.35\,A_s}{2}\right)$$

$$= -0.2 + 8.6875\,A_s - 1.175\,A_s \qquad A_s =$$

$A_s = 7.2$ — they have 3 #5's so no rebar needed

VI. BREADTHS

C.) STRUCTURAL BREADTH

CALCULATIONS(CONT'D)

JOHN MULHERN | V BREADTHS A) STRUCTURAL

Longitudinal shrinkage & temperature reinforcement

$A_s = 0.0018\, bh = 0.0018(12")(12") = 0.259\ in^2$ per foot of concrete

Use #4 @ 9 in o.c.

Using #5's from plans

$A = 0.31\ in^2$

need $\frac{0.259\ in^2}{\text{per 1 foot strip}} \pm \frac{0.31\ in^2}{X}$

$X \approx 14$ in but for ease 12" o.c

VI. BREADTHS

C.) STRUCTURAL BREADTH

CONCLUSION

The added load from the extra exterior surface area does not change the AHU-2 which just serves the auditorium. This will not affect energy costs too much as shown above. The fans are able to handle the existing load by an engineering check and do not require to be resized.

VII. CONCLUSION

A) LIGHTING

The new lighting design will save the owner a great deal more on energy costs. Some spaces had enough lighting fixtures to light two to three more rooms. Points were lost for lighting in many rooms that could easily have been attained. This new design is by far more energy efficient by designing for appropriate illuminance levels.

B) ELECTRICAL

Most 480Y/277V panelboards in this space were oversized for what load and reasonable spare capacity was needed. The lighting loads decreased significantly in large spaces such as the auditorium and lobby. The aluminum feeder savings estimate proved to not be worth the hassle of electricians dealing with this type. The reason for which the savings were so low is that there was a 480Y/277V switchboard on ever floor for all four electrical branches. This means that there was only one long run feeder run from the MDP to each floor. The other panelboards had short runs in their respective electrical rooms. Finally the SKM analysis proved useful for the short circuit analysis but caused problems for arc flash studies. The program

C) MECHANICAL

Most 480Y/277V panelboards in this space were oversized for what load and reasonable spare capacity was needed. The lighting loads decreased significantly in large spaces such as the auditorium and lobby. The aluminum feeder savings estimate proved to not be worth the hassle of electricians dealing with this type. The reason for which the savings were so low is that there was a 480Y/277V switchboard on ever floor for all four electrical branches. This means that there was only one long run feeder run from the MDP to each floor. The other panelboards had short runs in their respective
electrical rooms.

D) STRUCTURAL

0The current strip footing has the strength to hold up the extra dead load from the 4' of CMU wall with brick veneer. The footing did not even need rebar based on shear design. The other part of the strip footing resting on top of it was an assumed height because the firm does not display some dimensions most likely for liability issues that occurred in the past. The footing did need #5 rebar 12" O.C. though for shrinkage and temperature reinforcement

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THE IESNA LIGHTING HANDBOOK REFERENCE & APPLICATION

NATIONAL ELECTRICAL CODE 2008

IX. APPENDIX

LUMINAIRE & BREAKER SPECIFICATION SHEETS IN THIS SECTION