Electrical Systems Existing Conditions and Building Load Summary

AE 481W

Tech Report 2

Bucks County Justice Center

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Executive summary

This report is an analysis of the electrical system of the Bucks County Justice Center. Part 1 of the analysis develops design criteria base on the NEC, the IBC, and design practices as well as performing preliminary load calculations. Part 2 of this analysis documents the electrical system as designed including load calculations. Part 3 compares the design to the criteria and discusses areas that could be investigated further in order to see if efficiency or reliability can be improved.

The main electrical system utilizes a 3200 A unit substation that is fed by a 2000 KVA building transformer with a 34.5 KV primary and a 277/480 secondary. The building utilizes a dual voltage distribution system of 277/480 V and 120/208 V. A 1000 KW generator and a 100 KW UPS serve the emergency power distribution system. There are various low voltage systems throughout the building including audio visual, telecommunications, fire alarm, and an expansive security system.

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1. Part 1 - Electrical Systems Criteria and Scope of Work

1.1 Preliminary Load Calculation

Preliminary load calculation based on building type, SF, NEC lighting and receptacle loads/demand factors, HVAC, and specialty equipment

SF Method Electrical Loads

	Bulding Area	Electrical Load	Mechanical Load		Mech. Equip. Electrical load
Building Type	**(SF)**	**(W/SF)**	**(SF/Ton)**	**(Tons)**	**(W/ton)**
Office Building	273000	7	300	910	1750

Total Loads		
Electrical Load (KW)	**Mechanical Load (KW)**	**Total Load (KW)**
1911	1593	**3504**

NEC Loads

Lighting Loads (NEC Table 220.12)			
Occupancy Type	**Area SF**	**Electrical Load VA/SF**	**Electrical Load KVA**
Office Buildings	273000	3.5	**956**

Lighting loads are continuous so the demand factor is 125%

$(956\ KVA)(125\%) = \mathbf{1195\ KVA}$

Receptacle Loads (NEC 220.14(K))			
Occupancy Type	**Area SF**	**Electrical Load VA/SF**	**Electrical Load KVA**
Office Buildings	273000	1	**273**

Receptacle demand factor 100% for first 10 KVA and 50% for remaining KVA

$(10\ KVA) + (263\ KVA)(50\%) = \mathbf{141.5\ KVA}$

The Bucks County Justice Center will have telecom rooms on every floor and will house servers. Both of these items will greatly influence the load.

There are nine elevators in the building assume 30 HP 480V 3Φ motors

$$(9)(40\ FLA)\left(\frac{(\sqrt{3})(480)}{1000}\right) = 299\ KVA$$

For nine elevators a demand factor of 73% may be used

$$(299\ KVA)(73\%) = \mathbf{218\ KVA}$$

1.2 Local Utility

The local utility company is PECO Energy Company.

1.3 Preliminary Selection of Utility Rate Schedule

RATE-GS is only available for a maximum of 750kVA for transformers inside the building or 1500kVA for transformers outside of the building. Above this RATE-HT must be used which requires the customer to install, own, and maintain the transformer. Based on the preliminary load calculation this project will be RATE-HT.

1.4 Voltage

The primary distribution voltage for the building should be 277/480 V with all large mechanical equipment utilizing 480 V and smaller 1Φ equipment and lighting utilizing 277 V. A sub distribution system of 120/208 V should be used for receptacles and any remaining lighting and equipment.

1.5 Emergency Power Requirements - IBC

Group H (highrise)

IBC 403.4.8.2 requires standby power for the following:

1. Power and lighting for the fire command center (Section 403.4.6, Section 911)
2. Ventilation and automatic fire detection equipment for smokeproof enclosures
3. Elevators (Sections 1007.4)

IBC 403.4.9.1 requires emergency power for the following:

1. Exit signs and means of egress illumination required by Chapter 10
2. Elevator car lighting
3. Emergency voice/alarm communications systems (Section 907.5.2.2)
4. Automatic fire detection systems (Section 907.2.13.1)
5. Fire alarm systems (Section 907.2.13)
6. Electrically powered fire pumps

Estimation of Loads

For lighting assume 2% of the total lighting load

$(1195\ KVA)(2\%) = \boldsymbol{24\ KVA}$

For elevators assume all of the elevators with demand factor

218 KVA

For the fire pump assume 125 HP 480V 3Φ motor

$(156\ FLA)\left(\frac{(\sqrt{3})(480)}{1000}\right) = \boldsymbol{130\ KVA}$

For pressurization fans assume five 7.5 HP 480V 3Φ motors

$(5)(11\ FLA)\left(\frac{(\sqrt{3})(480)}{1000}\right) = \boldsymbol{46\ KVA}$

Total load of **418 KVA**

Voltage:
277/480 volts

Power Source:
Diesel Generator

1.6 Special occupancy requirements - NEC Chapter 5:

Article 518 – Assembly Occupancies

The section only applies to the portion of the building that is Assembly Occupancy (the courtrooms).

Control of the emergency systems must comply with Article 700.

The fixed wiring shall be metal raceways, flexible metal raceways, nonmetallic raceways encased in at least 2 inches of concrete, or Type MI, MC, or AC cable. Audio cable must comply with Article 640, communications must comply with Article 800, class 2 and class 3 circuits must comply with Article 725 and fire alarm circuits must comply with Article 760. Nonmetallic conduit and tubing may be used in courtrooms if they are concealed within a wall, ceiling, floor, etc. with at least a 15 minute fire rating.

The neutral conductor of feeders supplying solid-state phase control, 3-phase, 4-wire dimmer systems shall be considered as current carrying conductors for the purpose of ampacity adjustment.

1.7 Optional Backup Power

Potential non-code-required loads for backup would include the access control system, security screening equipment, surveillance systems, servers, and telecom equipment. A UPS would most likely be the best choice of backup power for these loads. Additionally, it may be desirable to backup certain computer workstations in order to minimize the chance of data loss. These may be backed up with individual UPS's or tied into the building UPS system depending on the owner's preference and budget.

Loads

Assume seven telecom rooms with three racks per room with an equipment load of 8 KW/rack and a cooling load of 4 KW/rack

$(7)(3)(12) = \mathbf{252\ KW}$

1.7 Priority Assessment

Reliability: High

Reliability is highly important because the right to a fair and timely trial is central to the justice system and a loss of power would cause a delay in court proceedings. Additionally, a delay could cause security problems and have large financial consequences.

Power quality – Medium

Power quality is of medium importance because the various computers and servers and other electronic devices require descent quality power.

Redundancy – High

Redundancy is highly important for the same reasons that reliability is important. A loss of power would cause a delay in court proceedings.

Low first cost – Medium

Low first cost is of medium importance because this is a taxpayer funded project and taxpayers don’t like high costs.

Low life cycle cost – High

Low life cycle cost is highly important because the building will be owned and operated by the county for the life of the building.

Flexibility – Low

Flexibility is of low importance because the building will be owned and operated by the same entity for the life of the building and the basic functions of the building will not change for the foreseeable future.

1.8 Low Voltage/Communication Systems

There are numerous low voltage and communication systems in this building as listed below:

Telephone/Data: To accommodate typical office functionality

Audio-visual equipment: For presentations in the courtrooms

Fire Alarm and Detection: Per IBC Section 907

Access Control: There are areas of varying security in this facility

Security/surveillance: A sophisticated system for monitoring and protecting the facility including security screening equipment.

1.9 Electrical Equipment Space Requirements

The required electrical equipment will require a substantial amount of space. It is recommended that a main electrical room house the generator, UPS, main transformer, and main switchgear. Every floor will have at least 2 electrical rooms (one per wing) with a transformer and at least one high voltage and one low voltage panel. NEC Article 110 has minimum required clearances for electrical equipment based on the equipment's voltage. There are also fire rating requirements for the rooms that house electrical equipment. NEC Article 250 Part II gives requirements for rooms housing transformers. IBC 402.4.8.1 requires the room that houses the generator be at least 2-hr fire rated.

Space Estimate

Main electrical room: building transformer, switch gear, generator, UPS, ATS's, and working space

Transformer and Switchgear
$(10)(20) = 200SF$

Generator
$(10)(30) = 300SF$

UPS and ATS's
$(10)(20) = 200SF$

$Main\ electrical\ Room\ Total\ = \mathbf{700SF}$

Electrical distribution: two rooms per floor with transformers, high and low voltage panels for both normal and backup power, and working space

$(2)(7)(100) = \mathbf{1400SF}$

Telecom: one room per floor with three racks, appropriate power panels, and working space

$(7)(150) = \mathbf{1050SF}$

$\underline{Building\ Total\ = \mathbf{3150SF}}$

2. Part 2 - Existing Electrical System

2.1 Load Summary

The following tables are a summary of the connected load for the building according to the panel schedules.

BUSS DUCT #1 (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**Load Code**
PANEL '6LP2'	120/208	35.4	RECEPTACLES, OFFICE FURNITURE	R
PANEL '5LP2'	120/208	23.6	RECEPTACLES, OFFICE FURNITURE	R
PANEL '4LP2'	120/208	21.4	RECEPTACLES, OFFICE FURNITURE	R
PANEL '3LP2'	120/208	21.7	RECEPTACLES, OFFICE FURNITURE	R
PANEL '2LP2'	120/208	34.6	RECEPTACLES, OFFICE FURNITURE	R
PANEL '1LP2'	120/208	42.8	RECEPTACLES, OFFICE FURNITURE	R
PANEL 'B1LP2'	120/208	41.7	RECEPTACLES, OFFICE FURNITURE	R
PANEL 'DPB21'	277/480	179.6	FANS FOR AHU 7, COMPACTOR, VAV CONTROLS, EF'S, SUB PANELS	S

BUSS DUCT #2 (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
PANEL '6LP1'	120/208	18.8	RECEPTACLES	R
PANEL '5LP1'	120/208	20.5	RECEPTACLES, AV RECEPTACLES	R
PANEL 4LP1'	120/208	20.9	RECEPTACLES, AV RECEPTACLES	R
PANEL 3LP1'	120/208	21.4	RECEPTACLES, AV RECEPTACLES	R
PANEL 2LP1'	120/208	16.6	RECEPTACLES, OFFICE FURNITURE	R
PANEL '1LP1'	120/208	21.9	RECEPTACLES, OFFICE FURNITURE	R
PANEL 'B1LP1'	120/208	16.7	RECEPTACLES	R

BUSS DUCT #3 (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
PANEL '6HP1'	277/480	96.4	LIGHTING, VAV CONTROL XFMR	L
PANEL '4HP1'	277/480	26.2	LIGHTING, LIGHTING RELAY CONTROLS, VAV CONTROL XFMR	L
PANEL '3HP1'	277/480	60.1	LIGHTING, LIGHTING RELAY CONTROLS, VAV CONTROL XFMR	L
PANEL '1HP1'	277/480	44.0	LIGHTING, LIGHTING RELAY CONTROLS, VAV CONTROL XFMR	L
PANEL 'DIM6'	277/480	15.0	LIGHTING	L
PANEL 'DIM4'	277/480	15.0	LIGHTING	L
PANEL 'DIM3'	277/480	15.0	LIGHTING	L

BUSS DUCT #4 (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
PANEL '6LP4'	120/208	22.6	RECEPTACLES, BAS PANEL	R
PANEL '5LP4'	120/208	15.7	RECEPTACLES, BAS PANEL	R
PANEL '4LP4'	120/208	18.0	RECEPTACLES, AV RECEPTACLES, BAS PANEL	R
PANEL '3LP4'	120/208	22.8	RECEPTACLES, AV RECEPTACLES, BAS PANEL	R
PANEL '2LP4'	120/208	48.7	RECEPTACLES, OFFICE FURNITURE	R
PANEL '1LP4'	120/208	42.8	RECEPTACLES, OFFICE FURNITURE	R
PANEL 'B1LP4'	120/208	40.6	RECEPTACLES, OFFICE FURNITURE	R
PANEL 'DPB22'	277/480	72.7	FANS FOR AHU 8, BOOSTER PUMP, VAV CONTROLS, SUB PANELS	S

AUTOMATIC TRANSFER SWITCH 'ATS-CR' (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
UPS	277/480	77.2	TELECOM, SECURITY SYSTEM, LIGHTING,	S
PANEL CR6	120/208	89.1	HEAT PUMPS	M
PUMP P-18	480	11.6		M
PUMP P-19	480	11.6		M
FC-1	120/208	14.0		M
PANEL CR1	120/208	44.3	HEAT PUMPS	M

AUTOMATIC TRANSFER SWITCH 'ATS-EP' (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
PANEL 'EPPH1'	277/480	252.7	ELEVATORS, SUB PANEL	M
PANEL 'EPPH2'	277/480	145.3	ELEVATORS, SUB PANEL	M
SF-1	277/480	11.6		M
SF-5	277/480	9.2		M
SF-3	277/480	9.2		M
SF-4	277/480	6.3		M
PANEL 'EPB21'	277/480	9.3	SF-2	M

AUTOMATIC TRANSFER SWITCH 'ATS-LS' (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
NORTH RISER	277/480	59.4	LIGHTING, RELAY PANELS, MOD'S	S
SOUTH RISER	277/480	27.1	LIGHTING, RELAY PANELS, MOD'S	S
GENERATOR INTEGRAL PANEL	120/208	25.0		M

OTHER LOADS (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
FIRE PUMP	480	140.0		M
CHILLER NO. 1	480	208.0		M
CHILLER NO. 2	480	208.0		M
PANEL 'PHM1'	277/480	451.8	AHU'S, PUMPS, CT'S, SUB PANEL	M
PANEL 'PHM2'	277/480	268.4	AHU'S, PUMPS, SUB PANEL	M

LOAD TOTALS	
LOAD TYPE	**LOAD** (KW)
RECEPTACLES (R)	569.1
LIGHTING (L)	271.7
SPECIAL EQUIPMENT (S)	415.9
MECHANICAL (M)	1915.4
TOTAL:	3172.2

2.2 Utility Rate Schedule

PECO RATE-HT is being utilized for this building.

2.3 Voltage

The building is served by a 34.5 KV utility line. The building utilizes a combination distribution system of 277/480 V and 120/208 V. The large mechanical equipment is 480 V, smaller single phase equipment is 277 V, most of the lighting is 277 V, and receptacles are 120 V.

2.4 Emergency Loads

There are four sets of loads on the generator; fire pump, life safety, emergency, and critical. The fire pump, life safety, and emergency are all code required loads. The critical loads are optional backup loads. The generator directly feeds the ATS for the fire pump. The remaining loads are fed from a 1600 A 480/277 V distribution switchboard.

The fire pump is a 125 HP 480 V 3Φ motor so its load is 130 KVA.

The life safety distribution system typically has 4 panels on every other floor. The panels are in high and low voltage sets for each wing of the building. The high voltage panels are for the lighting and feed the low voltage panels through a transformer. The low voltage panels are for the MOD's. The life safety system also feeds 32 circuits of each lighting dimming panel. Table 1 below shows the loads of the life safety system.

Table 1 – ATS-LS Loads

AUTOMATIC TRANSFER SWITCH 'ATS-LS' (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
NORTH RISER	277/480	59.4	LIGHTING, RELAY PANELS, MOD'S	S
SOUTH RISER	277/480	27.1	LIGHTING, RELAY PANELS, MOD'S	S
GENERATOR INTEGRAL PANEL	120/208	25.0		M
TOTAL LOAD (KW):		111.4		

The emergency distribution system has two sets of high and low voltage panels, with the high voltage panels feeding the low voltage panels through a transformer, in the penthouse for the elevator motors and associated devices. This system also provides power to the stair pressurization fans via a 480/277 V panel located in level B2. Table 2 below shows the loads for the emergency power system

Table 2 – ATS-EP Loads

AUTOMATIC TRANSFER SWITCH 'ATS-EP' (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
PANEL 'EPPH1'	277/480	252.7	ELEVATORS, SUB PANEL	M
PANEL 'EPPH2'	277/480	145.3	ELEVATORS, SUB PANEL	M
SF-1	277/480	11.6		M
SF-5	277/480	9.2		M
SF-3	277/480	9.2		M
SF-4	277/480	6.3		M
PANEL 'EPB21'	277/480	9.3	SF-2	M
TOTAL LOAD (KW):		443.6		

The fire alarm system is powered through the UPS. See Section 2.8 Optional Backup Power.

Describe the Generator

A 1000kW/1250kVA diesel generator provides emergency and backup power for the building. The generator is located on the roof, enclosed in a silencer cabinet, and sits on a 400 gallon fuel tank.

2.5 Special Occupancy

NEC Chapter 5
Article 518 – Assembly Occupancies

Dimmers are used to supply power to the lighting for the courtrooms. It is unclear if the dimmers are phase control or not; if they are then the neutral must be counted as a current carrying conductor for ampacity sizing.

2.6 Special Equipment

NEC Chapter 6

Article 605 - Office Furnishings
There is modular office furniture with integrated electrical distribution located in the various open office areas throughout the building.

Article 620 - Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts
There are nine elevators located throughout the building.

Article 640 - Audio Signal Processing, Amplification, and Reproduction Equipment
Each of the courtrooms is equipped with an audio amplification system.

Article 645 - Information Technology Equipment
There are several telecom rooms located throughout the building with data distribution racks and other related hardware.

Article 646 - Modular Data Centers
There are servers that are for the security system and also for general data located in the telecom rooms.

Article 660 - X-Ray Equipment
Security screening equipment which includes X-Ray machines are present at the entrances.

Article 695 - Fire Pumps
A 125 HP fire pump is located on Level B1

2.8 Electrical Equipment

The main transformer (T1) for the building is 34.5 KV:277/480 V 2000 KVA and is located in the main electrical room in the penthouse. Note that the transformer schedule in the design documents specifies, in error, the primary as 480Y277 V and the secondary as 208Y120 V.

Unit Substation No. 1 (USS1) is a 3200 A 277/480 V distribution panel located in the main electrical room.

Panel EO is a 1600 A 277/480 V panel that distributes power from the generator.

Main Risers and Feeders

There are four 277/480 V 800 A vertical busways that distribute power from USS1 to the main lighting and power panels.
Table 3 below lists the riser and feeder specifications for the building.

Table 3 – Risers and Feeders

Item Served	# Sets	Phase Size	Neutral Size	Ground Size	Conduit
Normal Distribution					
CH-1	1	500 KCMIL	-	2	3”
CH-2	1	500 KCMIL	-	2	3”
PHM1	3	300 KCMIL	300 KCMIL	1/0	2-1/2”
ATS-LS	1	1/0	1/0	6	2”
ATS-EP	2	350 KCMIL	350 KCMIL	1	2-1/2”
ATS-CR	2	3/0	3/0	3	2”
Bussways	3	300 KCMIL	300 KCMIL	1/0	2-1/2”
PHM2	3	300 KCMIL	300 KCMIL	1/0	2-1/2”
Fire Pump	1	4/0	-	4	MI Cable
Generator Distribution					
ATS-LS	1	1/0	1/0	6	2”
ATS-EP	2	350 KCMIL	350 KCMIL	1	2-1/2”
ATS-CR	2	3/0	3/0	3	2”
Fire Pump	1	4/0	-	4	MI Cable

Step-down Transformers

There are 39 step down transformers located throughout the building. All of them are 480:208Y120 V dry type transformers ranging in size from 15 to 75 KVA. See Table 4 below. Transformer 31 through transformer 40 are for emergency distribution.

Table 4 – Transformer Schedule

DESIGNATION	KVA	PRIMARY VOLTAGE	SECONDARY VOLTAGE	PHASE	TYPE	MOUNTING
T2	30	480	208Y/120	3	DRY	HUNG
T3	30	480	208Y/120	3	DRY	HUNG
T4	45	480	208Y/120	3	DRY	HUNG
T5	45	480	208Y/120	3	DRY	HUNG
T6	45	480	208Y/120	3	DRY	HUNG
T7	45	480	208Y/120	3	DRY	HUNG
T8	45	480	208Y/120	3	DRY	HUNG
T9	45	480	208Y/120	3	DRY	HUNG
T10	45	480	208Y/120	3	DRY	HUNG
T11	45	480	208Y/120	3	DRY	HUNG
T12	45	480	208Y/120	3	DRY	HUNG
T13	45	480	208Y/120	3	DRY	HUNG
T14	45	480	208Y/120	3	DRY	HUNG
T15	45	480	208Y/120	3	DRY	HUNG
T16	45	480	208Y/120	3	DRY	HUNG
T17	45	480	208Y/120	3	DRY	HUNG
T18	45	480	208Y/120	3	DRY	HUNG
T19	45	480	208Y/120	3	DRY	HUNG
T20	45	480	208Y/120	3	DRY	HUNG
T21	45	480	208Y/120	3	DRY	HUNG
T22	45	480	208Y/120	3	DRY	HUNG
T23	45	480	208Y/120	3	DRY	HUNG
T24	45	480	208Y/120	3	DRY	HUNG
T25	45	480	208Y/120	3	DRY	HUNG
T26	45	480	208Y/120	3	DRY	HUNG
T27	30	480	208Y/120	3	DRY	HUNG
T28	30	480	208Y/120	3	DRY	HUNG
T29	15	480	208Y/120	3	DRY	HUNG
T30	15	480	208Y/120	3	DRY	HUNG
T31	75	480	208Y/120	3	DRY	HUNG
T32	15	480	208Y/120	3	DRY	HUNG
T33	15	480	208Y/120	3	DRY	HUNG
T34	15	480	208Y/120	3	DRY	HUNG
T35	15	480	208Y/120	3	DRY	HUNG
T36	15	480	208Y/120	3	DRY	HUNG
T37	15	480	208Y/120	3	DRY	HUNG
T38	30	480	208Y/120	3	DRY	HUNG
T39	15	480	208Y/120	3	DRY	HUNG
T40	75	480	208Y/120	3	DRY	HUNG

Branch Panelboards - Specification Section 262416

A variety of branch panelboards in a variety of sizes are used. The most common panel size is 84 spaces. The NEMA rating for the surface mounted and recessed panelboards are based on the location type. See Table 5 below.

Table 5 – Panelboard NEMA Ratings

Location Type	NEMA 250 Rating
Indoor Dry and Clean Locations	Type 1
Kitchen Areas	Type 4X
Other Wet or Damp Indoor Locations	Type 4
Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids	Type 12

Phase, neutral, and ground buses are tin-plated aluminum.

Distribution Panelboards
NEMA PB 1, power and feeder distribution type.
Main circuit breaker
Bolt-on circuit breakers for 125 AF and smaller

Lighting and Appliance Branch Circuit Panelboards
NEMA PB 1, lighting and appliance branch-circuit type
Main circuit breaker
Bolt-on circuit breakers, replaceable without disturbing adjacent units

There are three 96 circuit 480/277 V dimming panels each of which has 32 circuits that are on the life safety system. The lighting control diagram designates the dimmers as 120 V, but the electrical riser diagram and the specified lighting fixtures indicate that the dimmers are 277 V

Table 6 and Table 7 on the following pages list the branch panelboards. The missing information was not available in the design documents.

Table 6 – Branch Panelboards

DESIGNATION	VOLTAGE	MAIN		BUSING	TYPE	SCR	MOUNTING	FED FROM
		RATING	TYPE					
1HP1	480/277	100	MLO	100	3-PH 4-W	30000	SURFACE	BUSSWAY #3
1LP1	480/277	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #2 VIA T20
1LP2	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #1 VIA T19
1LP4	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #4 VIA T22
2LP1	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #2 VIA T20
2LP2	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #1 VIA T17
2LP4	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #4 VIA T18
3HP1	480/277	100	MLO	100	3-PH 4-W	30000	SURFACE	BUSSWAY #3
3LP1	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #2 VIA T14
3LP2	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #1 VIA T13
3LP4	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #4 VIA T16
4HP1	480/277	100	MLO	225	3-PH 4-W	30000	SURFACE	BUSSWAY #3
4LP1	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #2 VIA T11
4LP2	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #1 VIA T10
4LP4	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #4 VIA T12
5LP1	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #2 VIA T6
5LP2	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #1 VIA T8
5LP4	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #4 VIA T9
6HP1	480/277	100	MLO	225	3-PH 4-W	30000	SURFACE	BUSSWAY #3
6LP1	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #2 VIA T5
6LP2	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #1 VIA T4
6LP4	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #4 VIA T7
B1LP1	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #2 VIA T21
B1LP2	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #1 VIA T23
B1LP4	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	BUSSWAY #4 VIA T24
B2HP1	480/277	100	MLO	100	3-PH 4-W	25000	SURFACE	DPB21
B2LP2	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	DPB21 VIA T25
B2LP4	208/120	150	MCB	225	3-PH 4-W	10000	SURFACE	DPB22
CR1	208/120	250	MCB	400	3-PH 4-W	10000	SURFACE	NECR VIA T40
CR6	208/120	250	MCB	400	3-PH 4-W	10000	SURFACE	NECR VIA T31
DIM3	480/277	100	MCB	-	3-PH 4-W	25000	SURFACE	BUSSWAY #3
DIM4	480/277	100	MCB	-	3-PH 4-W	25000	SURFACE	BUSSWAY #3
DIM6	480/277	100	MCB	-	3-PH 4-W	25000	SURFACE	BUSSWAY #3
DPB21	480/277	225	MLO	225	3-PH 4-W	25000	SURFACE	BUSSWAY #1
DPB22	480/277	225	MLO	225	3-PH 4-W	25000	SURFACE	BUSSWAY #4
EPB21	480/277	100	MLO	100	3-PH 4-W	22000	SURFACE	NEEP
EPPHH1	480/277	400	MLO	400	3-PH 4-W	40000	SURFACE	NEEP
EPPHH2	480/277	225	MLO	225	3-PH 4-W	40000	SURFACE	NEEP
EPPHL1	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	EPPHH1 VIA T29
EPPHL2	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	EPPHH2 VIA T30

Table 7 – Branch Panelboards cont.

DESIGNATION	VOLTAGE	MAIN		BUSING	TYPE	SCR	MOUNTING	FED FROM
		RATING	TYPE					
HNE21	480/277	100	MCB	225	3-PH 4-W	22000	SURFACE	NELS
HNE22	480/277	100	MCB	225	3-PH 4-W	22000	SURFACE	NELS
HNE41	480/277	100	MCB	225	3-PH 4-W	22000	SURFACE	NELS
HNE42	480/277	100	MCB	225	3-PH 4-W	22000	SURFACE	NELS
HNE61	480/277	100	MCB	225	3-PH 4-W	22000	SURFACE	NELS
HNE62	480/277	100	MCB	225	3-PH 4-W	22000	SURFACE	NELS
HNEB11	480/277	100	MCB	100	3-PH 4-W	22000	SURFACE	NELS
HNEB12	480/277	100	MCB	225	3-PH 4-W	22000	SURFACE	NELS
LNE21	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	HNE21 VIA T36
LNE22	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	HNE22 VIA T37
LNE41	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	HNE41 VIA T34
LNE42	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	HNE42 VIA T35
LNE61	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	HNE61 VIA T32
LNE62	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	HNE62 VIA T33
LNEB11	208/120	100	MCB	100	3-PH 4-W	10000	SURFACE	HNEB11 VIA T38
LNEB12	208/120	60	MCB	100	3-PH 4-W	10000	SURFACE	HNEB12 VIA T39
LNEB21	208/120	-	MLO	100	3-PH 4-W	10000	SURFACE	LNEB11
PHLP1	208/120	100	MCB	100	3-PH 4-W	10000	SURFACE	PHM1 VIA T2
PHLP2	208/120	100	MCB	100	3-PH 4-W	10000	SURFACE	PHM2 VIA T3
PHM1	480/277	-	MLO	800	3-PH 4-W	40000	SURFACE	USS1
PHM2	480/277	-	MLO	800	3-PH 4-W	-	SURFACE	USS1
SHPB21	480/277	-	MLO	100	3-PH 4-W	25000	SURFACE	DPB21
SHPB22	480/277	100	MLO	100	3-PH 4-W	25000	SURFACE	DPB22
SLPB21	208/120	100	MCB	100	3-PH 4-W	10000	SURFACE	SHPB21 VIA T27
SLPB22	208/120	100	MCB	100	3-PH 4-W	10000	SURFACE	SHPB22 VIA T28
UPS1A	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6A
UPS1B	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6B
UPS2A	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6A
UPS2B	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6B
UPS3	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6B
UPS4	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6A
UPS5A	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6A
UPS5B	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6B
UPSB1A	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6A
UPSB1B	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6B
UPSB2A	208/120	225	MLO	225	3-PH 4-W	10000	SURFACE	PDU6A
UPSB2B	208/120	225	MCB	225	3-PH 4-W	10000	SURFACE	PDU6B

Conductors – Specification Section 260513 & 260519

260513 – Medium Voltage

Table 8 – Medium Voltage Specifications

Item	Specification
Cable Type MV105	UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682.
Conductor	Copper
Conductor Stranding	Compact round, concentric lay, Class B
Strand Filling	Conductor interstices are filled with impermeable compound
Conductor Insulation	Ethylene-propylene rubber 35kV 133% insulation level
Shielding	Copper tape, helically applied over semiconducting insulation shield
Shielding and Jacket	Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket
Cable Jacket	Sunlight-resistant PVC
Installation	IEEE 576

260519 – Low Voltage

Table 9 – Low Voltage Specifications

Item	Specification
Copper Conductors	NEMA WC 70.
Conductor Insulation	NEMA WC 70 for Types THHN-THWN and XHHW.
Multiconductor Cable	NEMA WC 70 for metal-clad cable, Type MC with ground

Table 10 – Low Voltage Conductors

Use	Type
Feeders	Copper Solid for 10 AWG and smaller Stranded for 8 AWG larger
Branch Circuits	Copper Solid for 10 AWG and smaller Stranded for 8 AWG larger

Table 11 – Low Voltage Insulation

Use	Type
Exposed Feeders	THHN-THWN, Single Conductors in raceway
Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces	THHN-THWN, Single Conductors in raceway
Exposed Branch Circuits, Including in Crawlspaces	THHN-THWN, Single Conductors in raceway Or MC
Branch Circuits Concealed in Ceilings, Walls, and Partitions	THHN-THWN, Single Conductors in raceway Or MC
Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground	XHHW-2, Single Conductors in raceway
Class 1 Control Circuits	THHN-THWN, in raceway
Class 2 Control Circuits	THHN-THWN, in raceway
Fire Pump Feeders	Metal Sheathed Mineral Insulated Cables

Conduit – Specification Section 260533

Table 12 – Conduit Specifications

Type	Specification
Galvanized Rigid Conduit (GRC)	ANSI C80.1 and UL 6
Intermediate Metal Conduit (IMC)	ANSI C80.6 and UL 1242.
PVC Coated Steel Conduit	NEMA RN 1, 0.040 inch minimum coating
Electrical Metallic Tubing (EMT)	ANSI C80.3 and UL 797
Flexible Metal Conduit (FMC)	UL 1; zinc-coated steel
Liquidtight Flexible Metal Conduit (LFMC)	PVC jacket, UL 360
Rigid Nonmetallic Conduit (RNC)t	Type EPC-40-PVC NEMA TC 2 and UL 651

Table 13 – Conduit Locations

Location	Type
Outdoors	
Exposed Conduit	GRC
Concealed Conduit, Above Ground	GRC, IMC
Underground Conduit	RNC
Connection to Vibrating Equipment	LFMC
Indoors	
Exposed, Not Subject to Physical Damage	EMT, RNC
Exposed, Not Subject to Severe Physical Damage	EMT
Exposed and Subject to Severe Physical Damage	GRC
Concealed in Ceilings and Interior Walls and Partitions	EMT
Connection to Vibrating Equipment	FMC or LFMC
Damp or Wet Locations	GRC

Wiring Devices – Specification Section 262726

Table 14 – Receptacle Types

Item	Requirements	Configuration
Convenience Receptacles 125 V, 20 A	NEMA WD 1, NEMA WD 6,	5-20R, UL 498, and FS W-C-596
Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A	NEMA WD 1, NEMA WD 6	5-20R, UL 498, and FS W-C-596
GFCI Receptacles	NEMA WD 1, NEMA WD 6	UL 498, UL 943 Class A, and FS W-C-596
TVSS Receptacles	NEMA WD 1, NEMA WD 6	UL 498, UL 1449, and FS W-C-596
Twist-Locking Receptacles	NEMA WD 1, NEMA WD 6	L5-20R, and UL 498

Wall plates for finished spaces are to be type 301 stainless steel with a satin finish, for unfinished spaces galvanized steel, and for damp locations cast aluminum with spring loaded lift cover and listed for use in wet and damp locations. The securing screws are to be metal with heads to match the plate.

Table 15 below lists the colors for the wiring devices unless otherwise indicated or required by NFPA 70

Table 15 – Wiring Device Colors

Type	color
Normal power	Gray
Emergency power	Red
TVSS	Blue
Isolated-ground	Orange

Faceplate Type - Specification Section 260553

Equipment identification: Self-adhering or screw mounted laminated acrylic or melamine label with white letters on a dark gray background with a minimum letter height of 3/8”.

Motor Starters – Specification Section 262913 & 262923

Individual motor starters are utilized.

262913 – Enclosed Controllers

Full-voltage controllers must comply with NEMA ICS 2, general purpose, Class A. Enclosed controllers must be “quick-make, quick-break” non-reversing type with markings to indicate if they are on or off.

262923 – Variable-Frequency Motor Controllers

VFC's must comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C. They must have a minimum efficiency of 97 percent at 60 Hz, full load. They must have the capability for input from the BAS system to be delivered via 0 to 10-V, 4 to 20-mA, potentiometer using up/down digital inputs, or fixed frequency using digital inputs. The VFC's must have two 0 to 10-V or 4 to 20-mA outputs that can be programmed to be any of the following: output frequency (Hz), output current (load), DC-link voltage (V dc), motor torque (percent), motor speed (rpm), and set point frequency (Hz).

UPS System - Specification Section 263353

Size: 160KVA/144KW

Automatic Operation Requirements

Normal: load is supplied normal power through the rectifier-charger and inverter with the battery in parallel with the rectifier-charger

Abnormal: when the normal power deviates from the specifications the battery maintains constant power to the load without disturbance

If any component of the UPS fails normal power will be provided to the load without interruption.

Manual Operation

Turning the inverter off causes the static bypass transfer switch to transfer the load to normal power without interruption
Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

2.8 Optional Backup Power

The optional backup power is provided through the critical loads automatic transfer switch. These loads consist of the telecom equipment, servers, security system (including the XRAY and other scanning equipment), the heat pumps for the telecom/server rooms, and some lighting. The UPS system provides power for all of the critical loads except for the heat pumps. The UPS feeds two power distribution units which distribute the power to the rest of the panels. In general, there are two critical load panels per floor.

AUTOMATIC TRANSFER SWITCH 'ATS-CR' (277/480V)				
ITEM	**VOLTAGE**	**Load (KW)**	**LOADS**	**LOAD CODE**
UPS	277/480	77.2	TELECOM, SECURITY SYSTEM, LIGHTING,	S
PANEL CR6	120/208	89.1	HEAT PUMPS	M
PUMP P-18	480	11.6		M
PUMP P-19	480	11.6		M
FC-1	120/208	14.0		M
PANEL CR1	120/208	44.3	HEAT PUMPS	M
TOTAL LOAD (KW):		247.8		

2.9 Low Voltage Systems

Security system

Access control
Both exterior and interior doors utilize electronic locks and card swipes to limit access to secure areas. In general, each door has a 120 V circuit supplied to the control pack which feeds the equipment 24 V, but for doors in close proximity a central power pack is used.

Surveillance
A thorough surveillance system is utilized throughout the building. There are glass break sensors for the windows that are accessible from the outside, door contacts on doors for sensitive areas, and video cameras for the majority of the building. The surveillance devices are fed to security servers located in the telecom rooms. There are various displays and controls for the security system located in the control rooms on level B2. For the internal and exterior building mounted surveillance cameras CAT 6 UTP cable is used for video and CL3 cable is used to provide low voltage power. Fiber optic cable is used for exterior surveillance cameras that are mounted away from the building.

Fire System

The fire system consists of duct detectors, motor operated dampers, elevator control systems, strobes, horn strobes, and speakers among other components. All wiring is to be per manufacturer's recommendations and in minimum of ¾" conduit. All of the fire systems are tied into the fire command center that is located on level B2.

Telecom/data

There are sufficient data and telecom equipment for distribution throughout the building. All of the cables run to the telecom rooms on each floor. The backbone cabling is typically 25 strand CAT 3 cable, 12 strand single mode fiber cable and 6 strand multimode fiber cable. The conduit is typically EMT. Minimum separation between telecom cables and power devices must be maintained. For power cables when either cable is in metal conduit a clearance of 2" is required. 5" clearance is required for fluorescent light ballasts. When neither cable is in metal conduit the required clearance varies from 2" to 20' depending on the amount of power that the cable carries.

A/V

All of the courtrooms have an A/V system that includes cameras, microphones, speakers, amplifiers, input stations, touch panel control stations, an assistive listening system, and a projector.

Lighting Control

For lighting control, there are various types of low voltage push button stations, occupancy sensors, and daylight sensors that are networked with control units. For the courtrooms there are central dimming panels located on every other floor. For the conference rooms, offices, and other spaces there are control packs with four zones are utilized. All of the lighting controls are tied into the central lighting management system.

Integration of Controls Systems

The motorized projector screen and shades are controlled by the lighting system through a contact closure interface.

The same occupancy sensors are used for the HVAC and lighting systems. Each occupancy sensor has an isolated relay to separate the systems.

2.10 Electrical and Communication Spaces

The unit substation, generator, ups, and ATS's are located on the penthouse level. See Image 1 below.

Image 1 – Main Electrical Equipment Locations

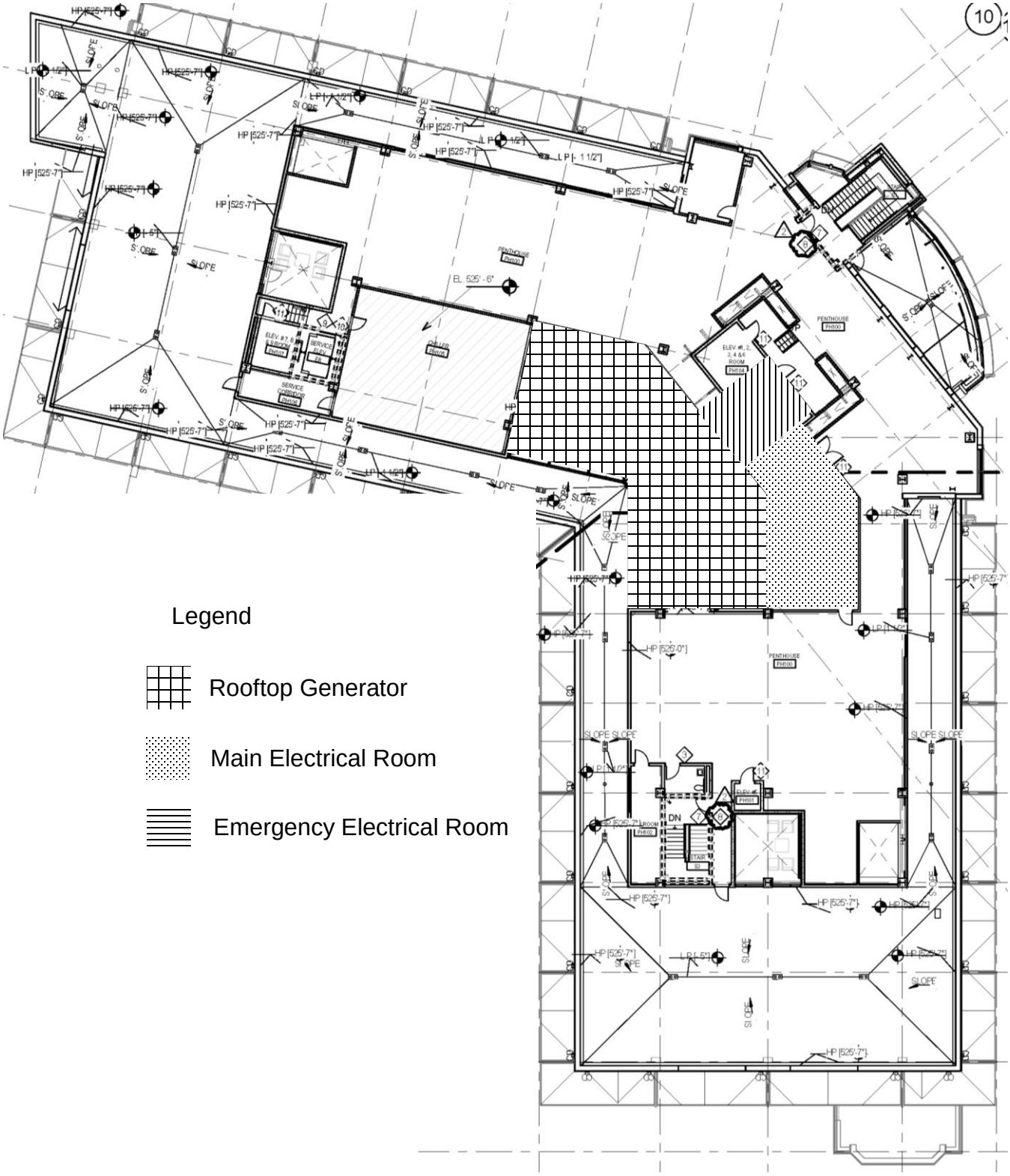


Table 16 – Electrical and Communications Equipment Rooms

Room Number	Room Name	Size (SF)	Contents
B2060	Fire Command Rm	77	ANN, FACP, Panelboard
B2035	Mech. Rm	396	T25, T27, Panelboards
B2033	Storage	89	T26, T28, Panelboards
B2___	Telecom Rm	125	
B2___	Telecom Rm	90	Panelboards
	B2 Total	**777**	
B1502	Elec. Rm	57	T38, T23, Panelboards
B1419	Telecom Rm	183	Panelboards
B1154	Elec. Rm	89	T24, T39, Panelboards, vertical busway#4
	B1 Total	**329**	
1502	Elec. Rm	57	T19, Panelboards, Busway #1
1441	Elec. Rm	175	T20, T221, Panelboards, Busway #2 & #3
1153	Elec. Rm	49	T22, Panelboards, Busway #4
1____	Telecom Rm	155	
	Level 1 Total	**436**	
2552	Elec. Rm	55	T36, T17, Panelboards, Busway #1
2303	Telecom Rm	144	Panelboards, Busway #2 & #3
2120	Elec. Rm	49	T37, T18, Panelboards, Busway #4
	Level 2 Total	**248**	
3557	Elec. Rm	53	T13, Panelboards, Busway #1
3051	Elec. Rm	104	T14, T15, Panelboards, Dim3, Busway #2 & #3
3157	Elec. Rm	60	T16, Panelboards, Busway #4
	Level 3 Total	**217**	
4557	Elec. Rm	53	T10, T34, Panelboards, Busway #1
4051	Elec. Rm	104	T11 , Panelboards, Dim4, Busway #2 & #3
4157	Elec. Rm	60	T12, T35, Panelboards, Busway #4
	Level 4 Total	**217**	
5557	Elec. Rm	53	T8, Panelboards, Busway #1
5051	Telecom Rm	104	Panelboards, Busway #2 & #3
5158	Elec. Rm	60	T9, Panelboards, Busway #4
	Level 5 Total	**217**	
6504	Elec. Rm	53	T4, T32, Panelboards, Busway #1
6351	Telecom Rm	170	T5, T6, PDU's, Panel Boards, Dim6, Busway #2 & #3
6108	Elec. Rm	47	T7, T33, Panelboards, Busway #4
	Level 6 Total	**270**	
PH108	Electrical	760	Unit Substation
PH109	Emr. Elec.	315	ATS's, UPS, Panelboards
PH_Courtyard	Generator	950	Generator
	Penthouse Total	**2025**	

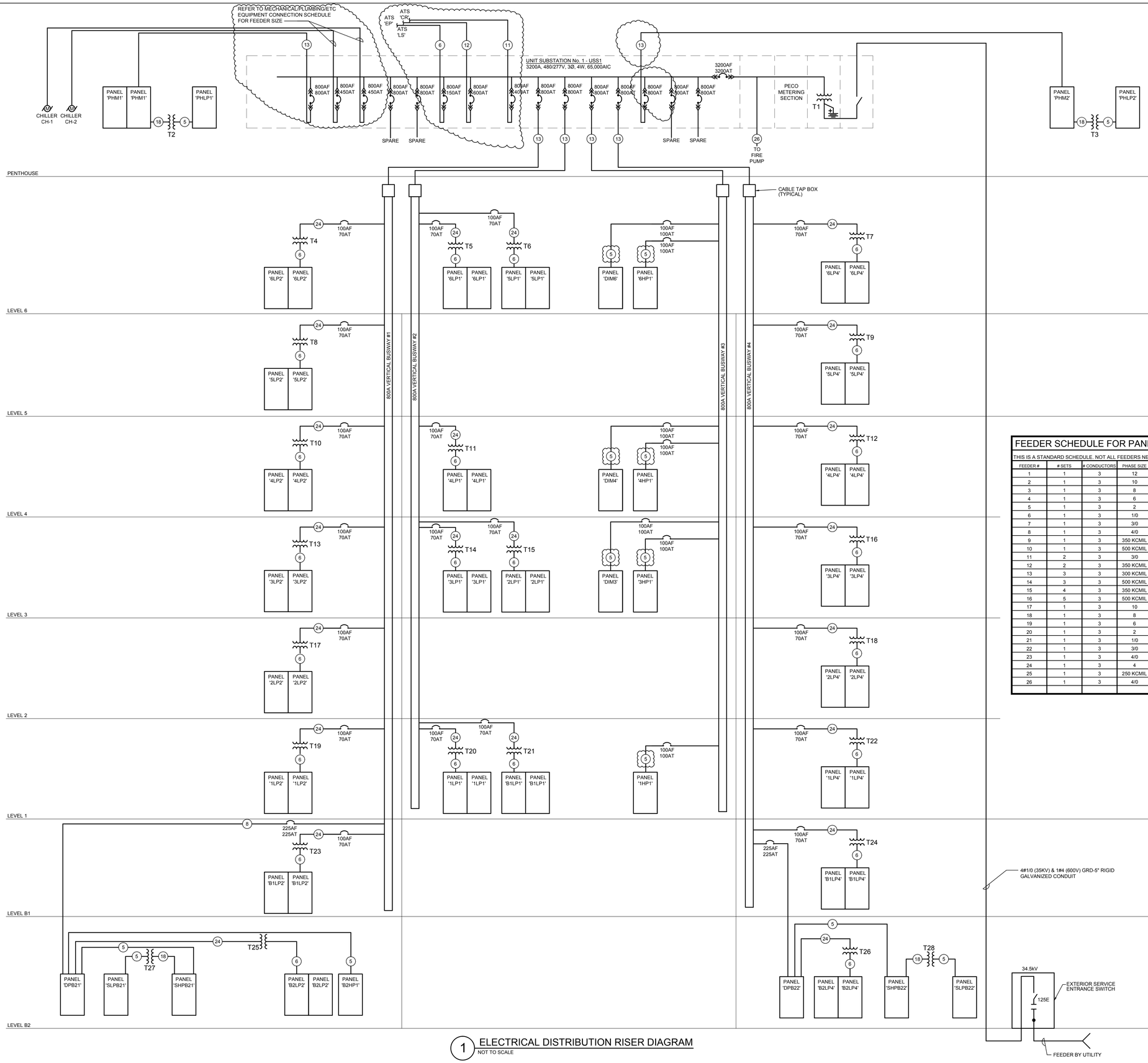
Grand Total:	**4736**
Percentage of gross SF:	**1.7%**

2.11 Alternative Energy Sources

There are not any plans to utilize solar, wind, or hydro power onsite for this project. A cogeneration system is not planned for this project. LEED certification is not being pursued for this project.

2.12 Single line/ riser Diagram

The normal power and the backup power single line diagrams are included on the following pages.



1 ELECTRICAL DISTRIBUTION RISER DIAGRAM
NOT TO SCALE

FEEDER SCHEDULE FOR PANELS AND SWITCHBOARDS

THIS IS A STANDARD SCHEDULE. NOT ALL FEEDERS NECESSARILY APPLY TO THIS PROJECT

FEEDER #	# SETS	# CONDUCTORS	PHASE SIZE	NEUTRAL SIZE	GROUND SIZE	CONDUIT SIZE	MAX. AMPS
1	1	3	12	12	12	3/4"	25
2	1	3	10	10	10	3/4"	35
3	1	3	8	8	10	3/4"	50
4	1	3	6	6	8	1"	65
5	1	3	2	2	8	1 1/4"	100
6	1	3	1/0	1/0	6	2"	150
7	1	3	3/0	3/0	6	2"	200
8	1	3	4/0	4/0	4	2 1/2"	230
9	1	3	350 KCMIL	350 KCMIL	3	3"	310
10	1	3	500 KCMIL	500 KCMIL	3	3"	380
11	2	3	3/0	3/0	3	2"	400
12	2	3	350 KCMIL	350 KCMIL	1	2 1/2"	600
13	3	3	300 KCMIL	300 KCMIL	1/0	2 1/2"	800
14	3	3	500 KCMIL	500 KCMIL	2/0	4"	1000
15	4	3	350 KCMIL	350 KCMIL	3/0	3"	1200
16	5	3	500 KCMIL	500 KCMIL	4/0	4"	1600
17	1	3	10	-	10	3/4"	30
18	1	3	8	-	10	3/4"	50
19	1	3	6	-	10	3/4"	65
20	1	3	2	-	8	1 1/4"	100
21	1	3	1/0	-	6	2"	150
22	1	3	3/0	-	6	2"	200
23	1	3	4/0	-	4	2"	230
24	1	3	4	-	8	1"	85
25	1	3	250 KCMIL	250 KCMIL	4	2 1/2"	255
26	1	3	4/0	-	4	MI CABLE	230

Project
BUCKS COUNTY JUSTICE CENTER
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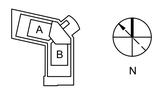
Key Plan



No.	Issue Description	YYYY-MM-DD
1	ISSUED FOR BID	2010/09/27

No.	Revision Description	YYYY-MM-DD
1	ADDENDUM No. 6	2010/11/10

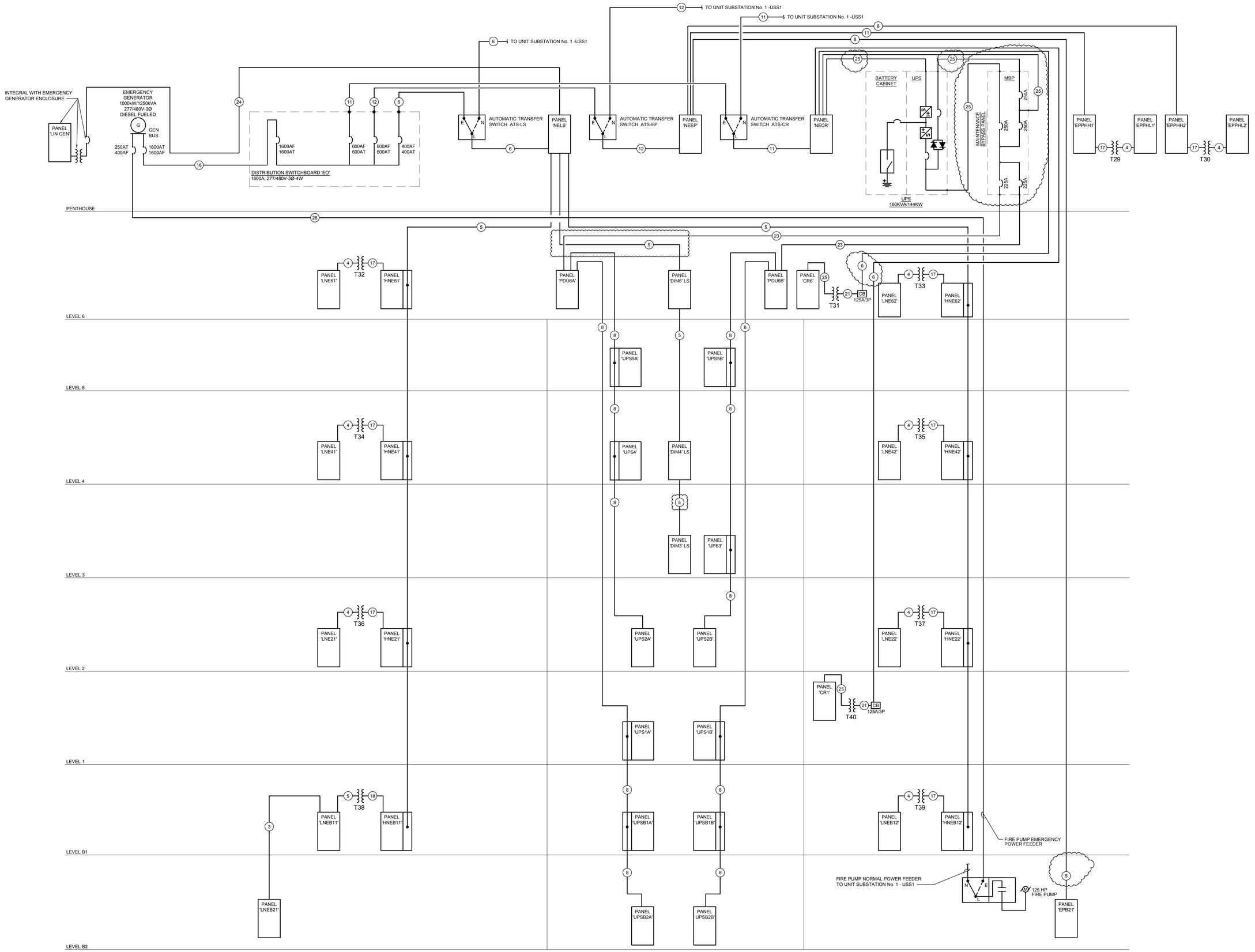
Drawn by BSH Reviewed by SPM

Project No 09.07001.01

Sheet Title
ELECTRICAL DISTRIBUTION RISER DIAGRAM

Original drawing is 30 x 42 Do not scale contents of this drawing

Sheet Number
E6001



1 EMERGENCY POWER DISTRIBUTION RISER DIAGRAM
NOT TO SCALE

Project
BUCKS COUNTY JUSTICE CENTER
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Prepared For
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Key Plan

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Sheet Title

EMERGENCY POWER DISTRIBUTION RISER DIAGRAM

Original drawing is 30 x 42 Do not scale contents of this drawing

Sheet Number

E6002

3. Part 3 – Evaluation of the Designed System Against Part 1 Criteria

3.1 Building Loads

Square Foot Method

The square foot method in Part 1 found the building load to be 3504 KVA where the design load is 3172 KVA. This estimate is quite reasonable.

NEC Method

The NEC method for Part 1 found the lighting load to be 1195 KVA where the design lighting load is 272 KVA. The estimate was incredible high, this is most likely due to the use of lighting fixtures with high efficacies and efficiencies. Another contributing factor could be that the whole building was estimated as an office building where a sizeable portion of the building is courtrooms which have an NEC lighting load of about 57% of what office buildings have. For receptacle load the estimate in Part 1 was 141.5 KVA where the design load is 569 KVA. In this case, the estimate was far lower than the design load. This may be due to the high number of receptacles that were placed throughout the building in order to accommodate the various offices. Another factor is that the loads in the design documents do not appear to apply a demand factor. This alone would cause nearly a 50% reduction in receptacle load.

3.2 Utility Rate Schedule

The utility rate schedule used is the same as the one that was proposed. This rate is the best option out of the available rates.

3.3 Voltage

The building is supplied by a single 34.5 KV utility feed. If the utility company would agree to it a dual feed system could be used with a main-tie-main substation in order to improve reliability.

The actual design uses a dual voltage interior distribution system as was recommended.

An investigation into adding DC distribution to the building would be an interesting study. This would involve changing all of the lighting to DC LED fixtures and changing all of the telecom equipment to equipment that accepts a DC input. This setup should improve efficiency by eliminating inverters and rectifiers from the system. Specifically, for the telecom equipment which is powered through the UPS it could eliminate an inverter and a rectifier.

3.4 Electrical Equipment

The design seems to be pretty typical for large size high quality electrical systems and utilizes pretty standard equipment and materials.

The design of the electrical system minimizes conductor run length and size by utilizing distributed electrical rooms and step down transformers. The hung transformers save space and maximize the use of allocated electrical rooms.

The estimated space requirement for electrical equipment was 3150 SF where the actual space allocation is 4736 SF. The estimate was close for the electrical rooms on each floor, but the major difference was in the size of the main electrical room. The design allocates 1075 SF of space for the building transformer, switchgear, and UPS and 950 SF of roof space for the generator where the estimate was only 400 SF and 300 SF respectively.

3.5 Emergency Power System

The design seems to meet all of the required codes. However, the fire control panel is shown on a panel that is on the critical distribution system. It should be located on the life safety system.

A natural gas powered generator could be investigated because of the reduced maintenance compared to a diesel generator. However, the AHJ would need to approve the natural gas source as uninterruptable. Even with this approval, it is still possible that the natural gas service could be interrupted in an emergency.

Because the generator is available the UPS is only needed to supply power for a short amount of time in the event of an outage. A flywheel system could be investigated to fill the gap between loss of power and the generator fire up. Flywheels require far less maintenance than UPS systems.

3.6 Optional Back-up Power

The estimated load from optional back up equipment was 168 KVA where according to the panel schedule the actual design has a load of 77 KVA on the UPS. This was most likely due to the uncertainty of what equipment would be located in the telecom rooms. The majority of the loads on the UPS are from the security system. The estimated mechanical load on the optional backup system was 84 KVA. The actual design has a mechanical load of 170 KVA on the critical power system.

The only receptacles that are on backup power are in the security office and the fire command center. It may be desirable to add other office receptacles to the optional backup system.

3.7 Controls System Integration

By using the same occupancy sensors for the BAS system and lighting system the number of required occupancy sensors is reduce which saves cost and helps to reduce clutter.

By integrating the shade control and projector screen control with the lighting system the ease of use for the system is improved.

3.8 Alternative Energy Sources

An investigation into the payback period for a photovoltaic array could be performed. If the PV array were to provide power to LED lighting designed for DC input no inverters or rectifiers would be required which would improve efficiency.