Technical Report 2: Electrical Systems Existing Conditions and Building Load Summary Report

100% Submission

Sherrerd Hall, Princeton University, NJ

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4 November 2009

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Sherrerd Hall | Princeton University

November 4, 2009

Executive Summary

This report provides a detailed narrative of the existing electrical systems of Sherrerd Hall, Department of Operations Research and Financial Engineering, at Princeton University in Princeton, NJ.

The report includes an overall summary of the scope of the electrical systems, as well as special characteristics of each system. There is a summary of the total building electrical loads and a check of the size of the existing main distribution equipment. In addition, the report includes a single-line diagram that describes the full extent of the electrical distribution system. There is also a narrative describing each of the communication systems in the building.

Although the current design provides an adequate solution for the building, there is room for improvement related to major equipment sizing. There is also considerable opportunity for enhancing energy performance by improving lighting and HVAC control systems to respond more appropriately to outdoor conditions.

General Building Statistics

Building name: Sherrerd Hall

Location and site: Princeton University, NJ

Building occupant name: Department of Operations Research and Financial Engineering

Occupancy / function types: Educational facility

Size: 47,000 SF

Number of stories above grade: 3 (total levels: 4)

Primary Projects Team:

- Owner: Princeton University
- Construction Manager: Barr & Barr, Inc., Builders
- Architect: Frederick Fisher and Partners
- Consulting Architect: KSS Architects
- Civil Engineer: Van Note—Harvey Associates
- Landscape Architect: Quennell Rothschild & Partners
- Structural Engineer: Robert Silman Associates, F.C.
- MEP Engineer: Loring Engineers
- Audio-Visual and Acoustics: Acentech Incorporated
- Lighting Design: Fisher Marantz Stone
- Curtain Wall: W.J. Higgins and Associates, Inc.

Dates of construction: February 2007 – July 2008

Project delivery method: Design-bid-build

[Section 1] Power Distribution Systems

Summary Description of Distribution System

Sherrerd Hall's overall electrical system is a radial system with one point of service entrance at the plan southeast corner of the building on the sub-grade level. Primary service is provided to Princeton University by PSE&G, and the building is tied to the campus system and receives power through a 750kVA oil-filled transformer that steps down the voltage from 4.160kV to a 480Y/277V, 3P, 4W voltage system. Emergency power is provided via an existing area generator in an adjacent campus building.

A 1200A main switchboard provides power to all equipment loads. Power at 480V is distributed to each floor, with transformers at power panels at each level to step down to 208Y/120V, 3P, 4W for receptacles and other small equipment. All other loads are connected to the 480Y/277V voltage system.

Utility Company Information

Sherrerd Hall is connected to the Princeton University campus system. The campus is served by Public Service Electric and Gas Company (PSE&G), the electric utility company that provides service to Princeton and several other counties in New Jersey. The company's address and website are as follows:

15 West State Street
Trenton, New Jersey 08604
http://www.pseg.com/companies/pseandg/overview.jsp

The building has been occupied since September 2008. Metered utility information has been requested for the building but has not yet been provided.

The available rates are as follows:

Generation

Day
June to September - 11.1044¢ per kwh
October to May - 9.3099¢ per kwh
Night
June to September - 8.2579¢ per kwh
October to May - 7.8027¢ per kwh

Transmission

June to September - 0.452¢ per kwh
October to May - 0.452¢ per kwh

Distribution Service

June to September - 1.2056¢ per kwh
October to May - 0.6126¢ per kwh

Service Entrance

Located at Princeton University, Sherrerd Hall is tied into the campus electrical system. The utility company provides electricity to the campus at a main location, and each building is fed through the campus distribution system. Princeton purchases primary service at 4.160kV, and all of the service entrance components are provided and owned by the university. Sherrerd Hall's individual electric use is monitored by the university with the use of an electronic meter located on the main bus of the switchboard.

The service entrance is located in the main electrical room (013 ELR) at the southeast corner of the building on the sub-grade level. Power is fed to the building via dual 5 kV feeders from the existing campus distribution system provided by the university. The single-ended secondary unit substation consists of an incoming line section with dual, stacked, manual 5kV primary selector switches and 6kV lightning arrestors, secondary transition sections, the main transformer, and a low voltage section with a drawout main and group-mounted feeder circuit breakers. In the main electrical room, there is a front and rear accessible switchboard with a power circuit breaker main device. The switchboard is close-coupled to the substation transformer and accepts a flexible bus connection from the transformer. A single main device is provided as the disconnecting means of the switchboard and has a minimum interrupting capacity rating of 35kAIC at rated voltage of the electrical service. A triple-pole low voltage power air circuit breaker with a trip unit rated 35kAIC at rated voltage is provided. The main breaker is individually mounted in a vertical section of the equipment and is manually operated and drawout mounted.

Emergency and standby power feeds into emergency panel EDP-G via a 125A 480Y/277V, 3P, 4W live feeder from an existing area generator at an adjacent campus building. A future feeder on panel EDP-G will provide emergency power to the campus building at 58 Prospect Street.

The transformer provides power directly into the main electrical room (013ELR) at the plan southeast corner of the building. The main utility transformer is mounted on a concrete pad in the electrical room. The primary transformer is rated at 750kVA, 4.160kV to 480Y/277V, 3P, 4W. It is an indoor silicone oil-filled type. The 1200A main switchboard is also located in electrical room 013ELR. This unit then provides power to other electrical rooms for distribution throughout the building. A transient voltage suppression system is also located at the service entrance.

Voltage Systems

The service entrance provides the building with a 480Y/277V, 3P, 4W voltage system. Most of the lighting operates at 277V off of a 480Y/277V, 3P, 4W feeder, with the exception of a custom lighting sculpture in the atrium that operates at 120V off of a 208Y/120V, 3P, 4W feeder. There is a transformer on each level to step down the voltage to power panels from 480V, and all of the receptacles, projectors, vending machines, copier machines, and other small equipment operate at 120V off of a 208Y/120V, 3P, 4W feeder. Motors that are 1/2 HP and larger operate at 460V, 3P, and those smaller than 1/2 HP operate at 115V, 1P.

Emergency Power System

During a power outage, some equipment and devices must continue to receive power, particularly for life safety purposes. Emergency and standby power feeds into emergency panel EDP-G via a 125A 480Y/277V, 3P, 4W live feeder from an existing area generator at an adjacent campus building. A future feeder on panel EDP-G will provide emergency power to the campus building at 58 Prospect Street.

Emergency distribution panel EDP-G feeds two automatic transfer switches. These automatic transfer switches are quadruple-pole and consist of a power transfer module and a control module. They are electrically operated by a single-solenoid mechanism energized from the generator, and the operating transfer time in either direction does not exceed one-sixth of a second. ATS-E serves the emergency and exit lighting, fire alarm system, elevator cab, and door security. ATS-S serves stand-by power loads such as sump pumps, sewage ejector pumps, freeze protection pumps, and receptacles in the mechanical and electrical rooms. When the primary electrical service is disrupted, a signal is sent to the generator for startup. ATS-E and ATS-S are activated at this time, and power for panels ELP-G and SDP-G is transferred from the main switchboard to the generator via panel EDP-G.

Locations of Switchgear

The main utility transformer is located in the main electrical room (013ELR) on the ground level at the plan southeast corner of the building. All of the major equipment is located in this main electrical room as well. The generator is located in an adjacent building. All lighting and appliance panel boards are located in the dedicated electrical room (116ELR, 218ELR, or 316ELR) on the floor that they are serving. The following tables document all major electrical equipment and panel boards.

MAJOR EQUIPMENT TABLE

TAG	TYPE OF EQUIPMENT	FLOOR LEVEL	ROOM NUMBER	ROOM NAME	DRAWING NUMBER
MSB	MAIN SWITCHBOARD	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
DP-G	DISTRIBUTION PANEL	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
EDP-G	EMERG. DISTRIBUTION PANEL	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
SDP-G	EMERG. DISTRIBUTION PANEL	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
MCC-G	MOTOR CONTROL CENTER	GROUND	012MEC	MECH RM	E1.0P, E2.1
T-1	TRANSFORMER	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
T-RP-G	TRANSFORMER	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
T-PP-G	TRANSFORMER	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
T-ERP-G	EMERGENCY TRANSFORMER	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
T-SPP-G	EMERGENCY TRANSFORMER	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
T-RP-1	TRANSFORMER	FIRST	116ELR	ELECT RM	E1.1P, E2.1
T-RP-2	TRANSFORMER	SECOND	218ELR	ELECT RM	E1.2P, E2.1
T-RP-3	TRANSFORMER	THIRD	316ELR	ELECT RM	E1.3P, E2.1
GENERATOR	GENERATOR	N/A	ADJACENT BLDG	N/A	E2.1
ATS-E	TRANSFER SWITCH	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
ATS-S	TRANSFER SWITCH	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1

PANEL BOARDS						
TAG	VOLTAGE SYSTEM	MAIN SIZE	FLOOR LEVEL	ROOM NUMBER	ROOM NAME	DRAWING NUMBER
PP-G	208Y/120V, 3P, 4W	150A MCB	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
RP-G	208Y/120V, 3P, 4W	150A MCB	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
LP-G	480Y/277V, 3P, 4W	100A MCB	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
ELP-G	480Y/277V, 3P, 4W	70A MCB	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
ERP-G	208Y/120V, 3P, 4W	100A MCB	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
SPP-G	208Y/120V, 3P, 4W	100A MCB	GROUND	013ELR	EIR ELECT RM	E1.0P, E2.1
RP-1	208Y/120V, 3P, 4W	150A MCB	FIRST	116ELR	ELECT RM	E1.1P, E2.1
LP-1	480Y/277V, 3P, 4W	100A MCB	FIRST	116ELR	ELECT RM	E1.1P, E2.1
RP-2	208Y/120V, 3P, 4W	150A MCB	SECOND	218ELR	ELECT RM	E1.2P, E2.1
LP-2	480Y/277V, 3P, 4W	100A MCB	SECOND	218ELR	ELECT RM	E1.2P, E2.1
RP-3	208Y/120V, 3P, 4W	150A MCB	THIRD	316ELR	ELECT RM	E1.3P, E2.1
LP-3	480Y/277V, 3P, 4W	100A MCB	THIRD	316ELR	ELECT RM	E1.3P, E2.1
PP-3	208Y/120V, 3P, 4W	100A MCB	THIRD	316ELR	ELECT RM	E1.3P, E2.1

Over-current Devices

Circuit breakers are the main source of over-current protection in the building. There is a 5kV, triple-pole low voltage power air circuit breaker with a trip unit rated 35kAIC at rated voltage at the utility service entrance. An individually mounted circuit breaker main device is located at the switchboard. This main breaker is electrically operated with a shunt trip. For all feeders rated 1200 amperes and below, there are group-mounted and bolt-on style molded case circuit breakers. The breakers have electronic solid-state trip units with integral metering functions that communicate with meters on the main and the feeders. These electronic metering features are described further in the special equipment section of this report below. There is also a single 175A rejection type fuse at the main service entrance after the primary switches and prior to the main transformer. The fuse is current limiting and has an interrupting capacity of 100,000 amperes RMS symmetrical.

The minimum short circuit rating for distribution panels is equal to the interrupting capacity of the lowest rated circuit breaker in the distribution panel board, but never less than 10,000 amperes RMS symmetrical. Distribution panels consist of Type 1 enclosed circuit breakers with an AIC rating of 10,000, 14,000, 22,000, 65,000, or 100,000. Nearly all individual panel boards contain a main circuit breaker, except for DP-G, which is main lugs only.

Lighting and power panels are the bolted circuit breaker type with single, two, and three pole branches. They have main and branch overcurrent interrupting devices consisting of circuit breakers with an AIC rating of 10,000, 14,000, 22,000, 65,000, or 100,000. Circuit breakers are the molded-case and bolted-in type consisting of the number of poles and ampere ratings required for the specific device. Two and three pole breakers are the common trip type. The breakers all have an indication for the on, off, and tripped positions of the operating handle, and when the breaker is tripped the handle assumes a position between the on and off positions. They have the quick-make and quick-break type toggle mechanism with inverse time trip characteristics and are trip-free upon overload or short circuit.

Automatic release is secured by a bimetallic thermal element releasing the mechanism latch. Additionally, a magnetic armature trips the breaker instantaneously for short circuit currents above the overload range. Locking tabs are provided on all circuit breakers serving emergency lighting, fire alarm system components, security system devices, and other emergency and critical equipment.

All separately mounted circuit breakers are the same type as for the panelboards with enclosures that are rated for dry, indoor locations.

Transformers

The building utilizes a total of eight transformers. The utility transformer (T-1) is located in the main electrical room (013ELR) on the sublevel at the plan southeast corner of the building. T-RP-G, T-PP-G, T-ERP-G, and T-SPP-G are located in the main electrical room 013ELR. T-RP-1, T-RP-2, and T-RP-3 are located in dedicated electrical rooms 116ELR, 218ELR, and 316ELR, respectively. T-RP-G, T-PP-G, T-RP-1, T-RP-2, and T-RP-3 serve the normal electrical power system, while T-ERP-G and T-SPP-G service the emergency loads. These pieces of equipment serve to step-down voltage to accommodate various loads. All transformers that are smaller than 75kVA are trapeze-mounted and supported by hanger rod isolators with the neoprene-in-shear element encased in a steel retainer housing. The following table provides specific information about each transformer.

INDIVIDUAL TRANSFORMER TABLE

TAG	PRIMARY VOLTAGE	SECONDARY VOLTAGE	SIZE	TYPE	TEMP. RISE	TAPS	MOUNTING	REMARKS
T-1	4160V,3PH,3W	480Y/277V,3PH,4W	750	LIQUID-FILLED	55/65 DEGREE C	(4) 2.5%	PAD MOUNTED IN 013 ELR	
T-RP-G	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	80 DEGREE C	(6) 2.5%	TRAPEZE MOUNTED	K-13 RATED
T-PP-G	480V,3PH,3W	208Y/120V,3PH,4W	75	DRY TYPE	80 DEGREE C	(6) 2.5%	TRAPEZE MOUNTED	
T-ERP-G	480V,3PH,3W	208Y/120V,3PH,4W	30	DRY TYPE	80 DEGREE C	(6) 2.5%	TRAPEZE MOUNTED	
T-SPP-G	480V,3PH,3W	208Y/120V,3PH,4W	30	DRY TYPE	80 DEGREE C	(6) 2.5%	TRAPEZE MOUNTED	
T-RP-1	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	80 DEGREE C	(6) 2.5%	TRAPEZE MOUNTED	K-13 RATED
T-RP-2	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	80 DEGREE C	(6) 2.5%	TRAPEZE MOUNTED	K-13 RATED
T-RP-3	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	80 DEGREE C	(6) 2.5%	TRAPEZE MOUNTED	K-13 RATED

Grounding

Grounding is depicted on E3.1, the electrical single line riser diagram.

Special Equipment

There is an integral transient voltage surge suppressor (TVSS) within the switchboard at the service entrance to the building. The TVSS has a symmetrical fault current rating greater than the rating of the connected panel. At the service entrance incoming location, the TVSS has a maximum surge current rating of 240kA. The device is capable of surviving a minimum of 20,000 C3 impulses without failure or performance degradation of more than ten percent. Downstream devices are capable of surviving a minimum of 5,000 C3 impulses without failure or performance degradation of more than ten percent. The TVSS is equipped with several monitoring features, including operational status indicating lights, an audible alarm, form C dry contacts for remote-monitoring purposes, and a transient voltage surge counter.

Metering equipment for circuit breakers is another form of special equipment in the building. The circuit breakers have electronic solid-state trip units with integral metering functions and use rating plugs to establish the nominal ampere rating of the breaker. The trip units have communications and are wired to a modbus concentrator and then to meters on the main and the feeders. The main breaker has 60 devices with adjustable settings and time delay, red and green indicating lights to show the status of open versus closed, and auxiliary switches. The breakers are equipped with a digital electronic trip unit. The protective trip unit consists of a solid state, microprocessor-based programmer, tripping means, and current sensors. The breaker trip units have the following metering functions: amperes, voltage, real power, apparent power, energy, and frequency. The metered values are displayed using digital numerals.

Lighting Loads

General ambient light is provided by a combination of linear fluorescent recessed and pendant-mounted fixtures and small-aperture compact fluorescent downlights. Metal halide sources are used to illuminate and accentuate the lobby atrium and feature wall. A light sculpture by Los Angeles artist Jim Isermann extends through the atrium and serves as a decorative element. The sculpture is composed of a metallic frame that supports rectangular light fixtures each faced with a lens and tilting in a variety of different directions. Nearly all luminaires in the building operate on 480Y/277 volts. More specific information for the H.I.D. ballast for Type FE is provided in Appendix B. The light sculpture in the atrium operates at 120 volts.

Daylighting is prevalent throughout the building, as a majority of the façade consists of transparent, translucent, and fritted glass panels. A large skylight over the central atrium allows daylight to penetrate the building core and to filter into spaces adjacent to the atrium.

Illuminance levels are based on the IESNA recommendations listed in Chapter 10 of the ninth edition of the Lighting Handbook, and lighting power density requirements are based on the ASHRAE 90.1 space-by-space method, where tradeoffs are permitted between spaces.

The following luminaire table provides a listing of each luminaire type and specific characteristics of each luminaire.

LUMINAIRE TABLE										
TAG	LIGHT SOURCE	LAMP	WATTS	NO. OF LAMPS	BALLAST TYPE	VOLTAGE	INPUT WATTS	BALLAST FACTOR	CURRENT START/ OPERATING	POWER FACTOR START/ OPERATING
FA	CFL	(1) 18W CFL 3000K	18	1	ELECTRONIC, RS	277	20	1.05	0.07	0.99
FA-1	CFL	(1) 18W CFL 3000K	18	1	ELECTRONIC, DIM	277	20.8	0.95	0.08	0.95
FB	FLUOR	(2) 28W T5 3500K	28	2	ELECTRONIC, PS	277	61	1.00	0.22	0.98
FC	FLUOR	(2) 28W T5 3500K	28	2	ELECTRONIC, PS	277	61	1.00	0.22	0.98
FC-1	FLUOR	(2) 28W T5 3500K	28	2	ELECTRONIC, DIM	277	64.5	1.00	0.25	0.95
FE	MH	(1) 35W PAR20 MH	39	1	ELECTRONIC	277	45	1.00	0.18	0.90
FF	FLUOR	(1) 21W T5 3500K	21	1	ELECTRONIC, PS	277	25	1.06	0.09	0.98
FF	QUAR	(2) 50W MR-16	50	2	-	277	100	1.00	0.36	1.00
FG	FLUOR	(1) 54W T5HO 3500K	54	1	ELECTRONIC, PS	277	62	0.99	0.25	0.90
FK	LED	LED IN RAIL	122	16 FT	ELECTRONIC	277	122	1.00	0.44	1.00
FL	CFL	(1) 26W CFL 3500K	26	1	ELECTRONIC, PS	277	29	1.10	0.11	0.98
FO	LED	LIGHT SCULPTURE LED	1000	-	-	120	1000	-	-	-
FP	FLUOR	(1) 32W T8 3500K	32	1	ELECTRONIC, IS	277	31	0.90	0.11	0.98
FQ	CFL	(1) 26W CFL 3500K	26	1	ELECTRONIC, PS	277	29	1.10	0.11	0.98
FR	CFL	(1) 18W CFL 3000K	18	1	ELECTRONIC, RS	277	20	1.05	0.07	0.99
FS	QUAR	(1) 50W MR-16	50	1	-	277	50	1.00	0.18	1.00
FW	FLUOR	(2) 28W T5 3500K	28	2	ELECTRONIC, DIM	277	64.5	1.00	0.25	0.95
FX	INCAN	(1) 60W G25	60	1	-	277	60	-	0.22	1.00
FY	CFL	(1) 26W CFL 3500K	26	1	ELECTRONIC, PS	277	29	1.10	0.11	0.98
FZ	CFL	(1) 42W CFL 3500K	42	1	ELECTRONIC, PS	277	46	0.98	0.17	0.98
LA	FLUOR	(2) 32W T8 3500K	32	2	ELECTRONIC, PS	277	65	1.00	0.24	0.98
LB	INCAN	(1) A100	100	1	-	277	100	-	0.36	1.00
X1	LED	INTEGRAL RED LED	7	1	-	277	7	-	0.03	1.00
X2	LED	INTEGRAL RED LED	7	1	-	277	7	-	0.03	1.00

Lighting Control

Manual switches and occupancy sensors are utilized throughout the building for control. In larger classroom and office spaces, the occupancy sensors are ceiling mounted. In small offices, the occupancy sensors are wall mounted at the switch. A more specialized control system with a Lutron Grafik Eye and preset lighting scenes is provided in the main conference room on the first level. There are occupancy sensors in all spaces except for stairs, mechanical and electrical rooms, server rooms, and other service spaces that fulfill the ASHRAE/IESNA 90.1 shutoff requirements.

Mechanical and Other Loads

Sherrerd Hall contains a variety of electrically powered equipment for mechanical, plumbing, audiovisual, and architectural systems. All equipment operates at either 480V or 120V. Mechanical equipment includes coils, fans, pumps, and heaters. Plumbing equipment includes pumps and electric hot water heaters. Architectural equipment includes the elevator, copy machines, and vending machines. Audiovisual equipment includes LCD projectors and television screens. Most equipment is located in mechanical and electrical rooms, with main equipment located at the ground level. The calculated loads for all major building equipment are included in the following tables, and the total load is summed in kilowatts.

MECHANICAL EQUIPMENT TABLE									
EQUIPMENT TAG	LOAD DESCRIPTION	LOAD MAGNITUDE	LOAD UNIT	MOTOR AMPS	VOLTAGE	PHASE	ASSUMED POWER FACTOR	LOAD IN KVA	LOAD IN KW
AHU-1	AIR HANDLING UNIT	30	HP	40.0	480	3	0.95	33.26	31.59
AHU-2	AIR HANDLING UNIT	40	HP	52.0	480	3	0.95	43.23	41.07
AHU-3	AIR HANDLING UNIT	25	HP	34.0	480	3	0.95	28.27	26.85
AC-1	AIR COND-SUPPLY FAN	1.5	HP	3.0	480	3	0.85	2.49	2.12
AC-1	AIR COND-ELEC REHEAT	15	KW	-	480	3	1.00	15.00	15.00
AC-1	AIR COND-IR HUMIDIFIER	4.8	KW	-	480	3	1.00	4.80	4.80
AC-2	AIR COND-SUPPLY FAN	1.5	HP	3.0	480	3	0.85	2.49	2.12
AC-2	AIR COND-ELEC REHEAT	9	KW	-	480	3	1.00	9.00	9.00
AC-3	AIR COND-SUPPLY FAN	1.5	HP	3.0	480	3	0.85	2.49	2.12
AC-3	AIR COND-ELEC REHEAT	9	KW	-	480	3	1.00	9.00	9.00
AC-3	AIR COND-IR HUMIDIFIER	4.8	KW	-	480	3	1.00	4.80	4.80
FCU-1	FAN COIL UNIT	320	W	3.6	120	1	0.75	0.43	0.32
FCU-2	FAN COIL UNIT	320	W	3.6	120	1	0.75	0.43	0.32
FCU-3	FAN COIL UNIT	320	W	3.6	120	1	0.75	0.43	0.32
FCU-4	FAN COIL UNIT	320	W	3.6	120	1	0.75	0.43	0.32
FCU-5	FAN COIL UNIT	530	W	5.9	120	1	0.75	0.71	0.53
RF-1	AHU-1 RETURN	10	HP	14.0	480	3	0.95	11.64	11.06
RF-2	AHU-2 RETURN	10	HP	14.0	480	3	0.95	11.64	11.06
RF-3	AHU-3 RETURN	7.5	HP	11.0	480	3	0.95	9.15	8.69
TE-1	TOILET EXHAUST	3/4	HP	1.6	480	3	0.85	1.33	1.13
KE-1	123 KITCHEN EXHAUST	1/4	HP	5.8	120	1	0.75	0.70	0.52
KE-2	223 KITCHEN EXHAUST	1/4	HP	5.8	120	1	0.75	0.70	0.52
KE-3	319 KITCHEN EXHAUST	1/4	HP	5.8	120	1	0.75	0.70	0.52
EF-1	011 MEC EXHAUST	2	HP	3.4	480	3	0.85	2.83	2.40
EF-2	ELEC RM EXHAUST	2	HP	3.4	480	3	0.85	2.83	2.40
EF-3	ELEC/TELCOM EXHAUST	1/2	HP	1.1	480	3	0.85	0.91	0.78
EF-4	012 MEC EXHAUST	3/4	HP	1.6	480	3	0.85	1.33	1.13
EF-5	221 PRINTER EXHAUST	1/8	HP	2.9	120	1	0.75	0.35	0.26
EF-6	305 MAIL EXHAUST	1/20	HP	0.4	120	1	0.75	0.05	0.04
EF-7	305 JANITOR EXHAUST	1/20	HP	0.4	120	1	0.75	0.05	0.04
EF-8	108 COPY RM EXHAUST	1/8	HP	2.9	120	1	0.75	0.35	0.26
EL-1	013 EMR EXHAUST	1/4	HP	5.8	120	1	0.75	0.70	0.52
CUH-1	CABINET UNIT HEATER	1/20	HP	0.4	120	1	0.75	0.05	0.04
CUH-2	CABINET UNIT HEATER	1/20	HP	0.4	120	1	0.75	0.05	0.04
CUH-3	CABINET UNIT HEATER	1/15	HP	0.5	120	1	0.75	0.07	0.05
CUH-4	CABINET UNIT HEATER	1/20	HP	0.4	120	1	0.75	0.05	0.04
CUH-5	CABINET UNIT HEATER	1/15	HP	0.5	120	1	0.75	0.07	0.05
UH-1	STEAM UNIT HEATER	1/8	HP	2.9	120	1	0.75	0.35	0.26
UH-2	STEAM UNIT HEATER	1/8	HP	2.9	120	1	0.75	0.35	0.26
UH-3	STEAM UNIT HEATER	1/25	HP	0.3	120	1	0.75	0.04	0.03
UH-4	STEAM UNIT HEATER	1/8	HP	2.9	120	1	0.75	0.35	0.26
UH-5	HOT WTR UNIT HEATER	1/8	HP	2.9	120	1	0.75	0.35	0.26
FM-CHW	FLOW METER	1.08	KW	-	120	1	1.00	1.08	1.08
FM-STM	FLOW METER	1.08	KW	-	120	1	1.00	1.08	1.08

MECHANICAL EQUIPMENT TABLE (CONTINUED)									
EQUIPMENT TAG	LOAD DESCRIPTION	LOAD MAGNITUDE	LOAD UNIT	MOTOR AMPS	VOLTAGE	PHASE	ASSUMED POWER FACTOR	LOAD IN KVA	LOAD IN KW
HWP-1	HOT WATER PUMP	5	HP	7.6	480	3	0.95	6.32	6.00
HWP-2	HOT WATER PUMP	5	HP	7.6	480	3	0.95	6.32	6.00
HWP-3	HOT WATER PUMP	1	HP	2.1	480	3	0.85	1.75	1.48
HWP-4	HOT WATER PUMP	1	HP	2.1	480	3	0.85	1.75	1.48
HWP-5	HOT WATER PUMP	1	HP	2.1	480	3	0.85	1.75	1.48
HWP-6	HOT WATER PUMP	1	HP	2.1	480	3	0.85	1.75	1.48
CHWP-1	CHILLED WATER PUMP	10	HP	14.0	480	3	0.95	11.64	11.06
CHWP-2	CHILLED WATER PUMP	10	HP	14.0	480	3	0.95	11.64	11.06
FPP-1	FREEZE PROTECTION PUMP	1.5	HP	6.0	480	3	0.85	4.99	4.24
FPP-2	FREEZE PROTECTION PUMP	1.5	HP	6.0	480	3	0.85	4.99	4.24
FPP-3	FREEZE PROTECTION PUMP	1	HP	2.1	480	3	0.85	1.75	1.48
CP-1	CONDESNSATE PUMP	10	HP	14.0	480	3	0.95	11.64	11.06
CP-2	CONDESNSATE PUMP	10	HP	14.0	480	3	0.95	11.64	11.06

TOTAL: 267.19 kW

PLUMBING EQUIPMENT TABLE									
EQUIPMENT TAG	LOAD DESCRIPTION	LOAD MAGNITUDE	LOAD UNIT	MOTOR AMPS	VOLTAGE	PHASE	ASSUMED POWER FACTOR	LOAD IN KVA	LOAD IN KW
BP	DUPLEX BOOSTER PUMPS	7.5	HP	11.0	480	3	0.95	9.15	8.69
SE-1	SEWAGE EJECTOR PUMP	5	HP	7.6	480	3	0.95	6.32	6.00
SP-1	DUPLEX SUMP PUMP	1	HP	2.1	480	3	0.85	1.75	1.48
SP-3	CONDENSATE SUMP PUMP	1/2	HP	9.8	120	1	0.85	1.18	1.00
EWH-1	ELECTRIC HOT WTR HTR	6	KW	-	480	1	1.00	6.00	6.00
EWH-2	ELECTRIC HOT WTR HTR	6	KW	-	480	1	1.00	6.00	6.00
EWH-3	ELECTRIC HOT WTR HTR	0.75	KW	-	120	1	1.00	0.75	0.75
EWH-4	ELECTRIC HOT WTR HTR	1.5	KW	-	120	1	1.00	1.50	1.50

TOTAL: 31.42 kW

ARCHITECTURAL EQUIPMENT TABLE									
EQUIPMENT TAG	LOAD DESCRIPTION	LOAD MAGNITUDE	LOAD UNIT	MOTOR AMPS	VOLTAGE	PHASE	ASSUMED POWER FACTOR	LOAD IN KVA	LOAD IN KW
VEND-1	VENDING MACHINE 1	0.50	KVA	-	120	1	0.95	0.50	0.48
VEND-2	VENDING MACHINE 2	0.50	KVA	-	120	1	0.95	0.50	0.48
C-1	COPIER 102	1.00	KVA	-	120	1	0.95	1.00	0.95
C-2	COPIER 103	1.00	KVA	-	120	1	0.95	1.00	0.95
C-3	COPIER 104	1.00	KVA	-	120	1	0.95	1.00	0.95
C-4	COPIER 105	1.00	KVA	-	120	1	0.95	1.00	0.95
C-5	COPIER 108	1.00	KVA	-	120	1	0.95	1.00	0.95
EC-1	ELEVATOR CAB	0.25	KVA	-	120	1	0.95	0.25	0.24
EC-2	ELEVATOR CAB	0.25	KVA	-	120	1	0.95	0.25	0.24
ELEV	ELEVATOR	30.00	HP	40.00	480	3	0.95	33.26	31.59

TOTAL: 37.77 kW

AUDIOVISUAL EQUIPMENT TABLE									
EQUIPMENT TAG	LOAD DESCRIPTION	LOAD MAGNITUDE	LOAD UNIT	MOTOR AMPS	VOLTAGE	PHASE	ASSUMED POWER FACTOR	LOAD IN KVA	LOAD IN KW
PROJ-1	RM 001 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PROJ-2	RM 002 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PROJ-3	RM 003 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PROJ-4	RM 004 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PROJ-5	RM 101 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PROJ-6	RM 110 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PROJ-7	RM 119 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PROJ-8	RM 122 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PLASMA	PLASMA DISPLAY	0.50	KVA	-	120	1	0.95	0.50	0.48
PROJ-9	RM 211 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
PROJ-10	RM 222 PROJECTOR	0.30	KVA	-	120	1	0.95	0.30	0.29
							TOTAL:	3.33	kW

Service Entrance Size

The following are three service entrance sizing methods. The Square Foot Method is used during the conceptual and schematic design phases to estimate a general service entrance size based on the building type and area. The NEC Loading Method is part of design development and uses the total building area or the area specific to that load type, multiplied by the VA/SF for the specific load category. This method provides a more accurate estimate of the sizing. The final method consists of using the actual connected loads in the building, detailed above, multiplied by specific demand factors that account for system usage. This Actual Loading Method is used in industry when creating construction documents. The value calculated using the Actual Loading Method should be the closest to the actual service entrance size actually installed in the building. Loads considered with the Actual Loading Method are actual values provided in the existing construction documents and detailed above in specific tables for each load category.

SERVICE ENTRANCE SIZE: SQUARE FOOT METHOD			
BUILDING TYPE	AREA (SF)	VA/SF	VA
COLLEGE BUILDINGS: CLASSROOM BUILDING	47000	12	564000
		TOTAL KVA	564
		TOTAL CURRENT AT 480V	678.4
		RECOMMENDED SWITCHBOARD SIZE	800A

SERVICE ENTRANCE SIZE: NEC LOADING			
LOAD TYPE	AREA (SF)	VA/SF	VA
LIGHTING (DEMAND FACTOR = 1)	47000	3	141000
RECEPTACLES (APPLY DEMAND FACTOR OF 0.5 FOR VA GREATER THAN 10000)	47000	1	28500
FANS	47000	2	94000
COOLING	47000	8	376000
ELECTRIC WATER HEATERS (QUANTITY: 4)	-	-	240000
PUMPS	47000	2	94000
ELEVATORS (QUANTITY: 1)	-	-	50000
		TOTAL KVA	1023.50
		TOTAL CURRENT AT 480V	1231.08
		RECOMMENDED SWITCHBOARD SIZE	1600A

SERVICE ENTRANCE SIZE: ACTUAL LOADING			
LOAD TYPE	CONNECTED LOAD (VA)	DEMAND FACTOR	DEMAND LOAD (VA)
LIGHTING	38380	1	38380
RECEPTACLES	195050	1 for first 10000 VA, 0.5 for more	102525
FANS	52713	0.8	42170.4
COOLING	149768	1	149768
ELECTRIC WATER HEATERS	14250	1	14250
PUMPS	96286	0.8	77028.8
ELEVATORS	33255	1	33255
		TOTAL KVA	457.38
		TOTAL KVA (ADD 20% FOR SPARE CAPACITY)	571.72
		TOTAL CURRENT AT 480V	550.14
		TOTAL CURRENT AT 480V (ADD 20% FOR SPARE CAPACITY)	687.67
		RECOMMENDED SWITCHBOARD SIZE	800A

NOTES:
1. Summed VA loads for each category are taken from the equipment tables provided above for mechanical, plumbing, and architectural equipment.
2. Receptacle loads are taken from the appliance panel board schedules.
3. Total lighting load is calculated by summing the product of VA per fixture and quantity of fixture for all types.
4. Pumps include mechanical and plumbing equipment.

SERVICE ENTRANCE SIZING TABLE 1			
PHASE	LOAD-KVA	VOLTAGE SYSTEM	LOAD-AMPS
CONCEPTUAL/SCHEMATIC DESIGN	564	480Y/277V, 3P, 4W	678.4
DESIGN DEVELOPMENT	1023.50	480Y/277V, 3P, 4W	1231.08
WORKING DRAWINGS	571.72	480Y/277V, 3P, 4W	687.67

SERVICE ENTRANCE SIZING TABLE 2			
SERVICE ENTRANCE	SIZE-AMPS	VOLTAGE SYSTEM	CAPACITY-KVA
ACTUAL CONDITIONS-SERVICE ENTRANCE 1	1200A	480Y/277V, 3P, 4W	997.66
SUMMARY-VA/SF (TOTAL OF 47,000 SF)	21.23		

When comparing all three methods, the Square Foot Method was actually the smallest. This is due to the fact that the VA/SF was underestimated for this building type. The NEC Loading Method provides the highest estimate of the service entrance size. The assumed load under this method of 60kW for electric hot water heaters most greatly affects the sizing to be overestimated. The actual electric hot water heaters are no larger than 6kW. The Actual Loading Method value is slightly smaller than the Square Footage Method, though the values differ by little. Overall, the actual conditions service entrance size used for the existing system is higher than that calculated using the actual loading method. This is likely due to the fact that a spare is provided in the main switchboard for providing future service to another campus building. Many of the panel boards are also not fully utilized in order to leave room for future expansion.

Environmental Stewardship Design

The building is being designed as if to achieve a LEED Certified rating. Princeton University does not actually apply for LEED, however. There are no specifically green electrical systems that are to be implemented. The allowable lighting power density specified by ASHRAE Standard 90.1 was closely followed in the lighting design. Occupancy sensors are also used in most spaces to conserve energy when spaces are not in use.

A great deal of the spaces have access to daylighting, and a daylight responsive dimming alternative is included in the drawings for the perimeter offices. This alternative was not actually installed, but consideration for this alternative will be made for the redesign.

Design Issues

There were no major design issues during the design of Sherrerd Hall's electrical system identified by the owner.

Single-Line Diagram Drawing List

The following drawings were used in creating a single-line diagram:

E3.1 Electrical: Single Line Riser Diagram [Included in Appendix A]
E3.2 Electrical: Power Riser Diagram [Included in Appendix A]
E2.1 Electrical: Power Part Plans and Electrical Room Section

Single-Line Diagram

The single-line diagram is included in Appendix A.

[Section 2] Communication Systems

Fire Alarm System

The overall functions of the fire alarm system are to transmit an alarm to the Princeton Stanhope Hall Public Safety Station, alert the building occupants, supervise each device for conditions which would impair proper system operation, annunciate such abnormal conditions, and control such actions as elevator recall, air handling unit operation, and electronic door lock release. The fire alarm system consists of ADA compliant strobes and audible horns. It includes manual fire alarm pull stations, smoke detectors, duct mounted smoke detectors, heat detectors, sprinklers, tamper switches, water flow switches, fire smoke dampers, pressure switches, annunciator panels, and a fire alarm control panel. The main fire alarm control panel is located in the EIR Electrical Room (013ELR) on the sub-grade level. All other devices are spread throughout the building according to fire protection codes.

An addressable control module relay and a 120V circuit connection via relay are provided for each fire smoke damper for damper control via the fire alarm system. Fire smoke dampers are zoned per floor, and activation of any smoke detector on the floor closes all fire smoke dampers on the same floor. All air handling units shut down when the ground floor fire smoke dampers are closed. There are control modules in the elevator machine room for elevator recall and power shut down. Duct mounted smoke detectors are zoned per the air handling unit system. Activation of duct detectors shuts down associated air handling units (supply and return fans).

Audiovisual System

Various spaces throughout the building contain speakers, flat panel displays, and projector-screen combinations for the purposes of aiding in lectures and instruction and announcing department information. In Lecture Hall 101, projection of video and computer graphics is provided via an LCD video projector. Playback of stereo soundtracks and speech reinforcement are provided through ceiling-mounted speakers. Control of the AV equipment and projection screen is via an AV control system with a touch screen control panel that is programmed in accordance with the Princeton University Standard. For all standard Princeton classroom and seminar room systems, there are LCD video projectors for presentations. Wall-mounted loudspeakers on either side of the projection screen allow for playback of stereo soundtracks. Control and signal switching of equipment in these spaces is via an integrated button panel, input plate, and projector-mounted receiver and controller. There are portable projectors with spare cables available for any room equipped with a screen.

Aside from lecture equipment, there is a digital signage display located in the lobby for general department announcements, scheduling information, and weather and news information. A wall-mounted LCD and miniature digital signage receiver for display are located along the plan west wall of the lobby. In the Undergraduate Lounge on the first level, a flat-panel TV with a DVD/VCR combination player is mounted on a fixed stand.

Telephone/Data System

The conduit and pathways for the telephone/data system are shown on the electrical drawings in a riser diagram. However, the actual wiring for this system is not shown on these drawings and was supplied

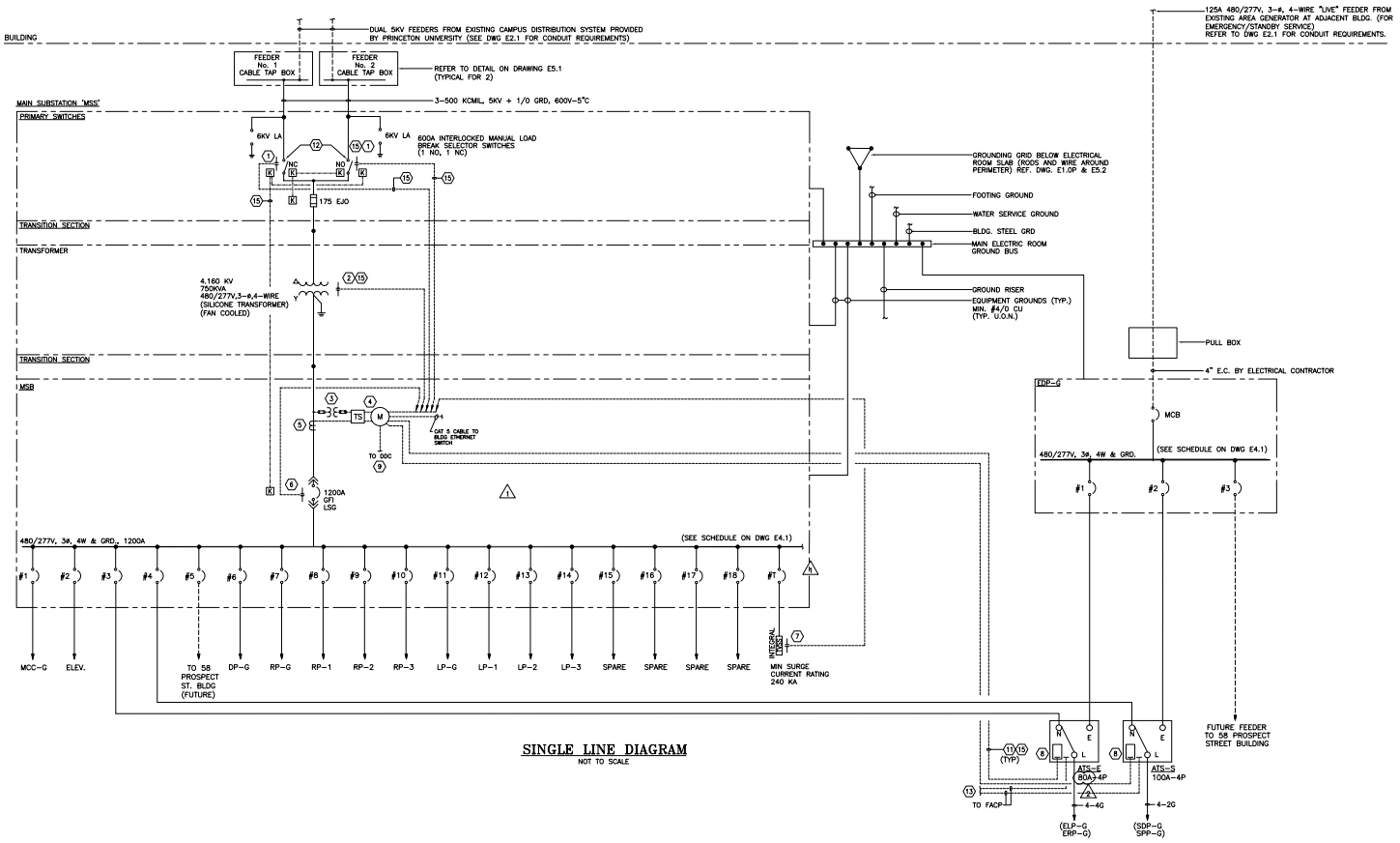
by a third party under a separate contract that was not included in the original scope of work for this project contract.

Security System

The security system consists of card readers at Doors 101, 102, 103, and 104. These card readers allow for limited access.

[Appendix A] Single Line Diagram and Existing Drawings

[Joseph Loring Engineers] E3.1 Electrical: Single Line Riser Diagram
[Joseph Loring Engineers] E3.2 Electrical: Power Riser Diagram
[Jamie Devenger] E1.0 Electrical: Single Line Diagram



SINGLE LINE DIAGRAM

NOT TO SCALE

SPECIFIC NOTES:

1. AUX POSITION SWITCH ON 5KV INTERRUPTER SWITCH. CLOSED WHEN MAIN SWITCH IS CLOSED.
2. GANGED TRANSFORMER ALARM CONTACT. CLOSED ON HIGH TEMP, LOW LEVEL, ETC.
3. (3) VT'S WITH 120 VAC SECONDARIES.
4. POWER MEASUREMENT METER WITH TEST SWITCH. METER ACCEPTS UP TO EIGHT DIGITAL INPUTS (DI).
5. (3) CT'S WITH 5 AMP SECONDARIES AND MULTI-RATIO TAPS ALL WIRED OUT TO ACCESSIBLE TERMINATION BLOCKS.
6. AUX. CONTACT ON POWER CIRCUIT BREAKER. CLOSED WHEN BREAKER IS CLOSED.
7. TVSS ALARM CONTACT. CLOSED WHEN TVSS IN ALARM.
8. ATS WITH MODBUS COMMUNICATION CARD.
9. KWH PULSE OUTPUT TO NEAREST DDC CONTROL CABINET.
10. NOT USED.
11. MODBUS RS-485 WIRING (BELDEN 9841 OR APPROVED EQUAL) (TYPICAL) PROVIDE WIRE AND CONDUIT.
12. STACKED KENNEY SWITCHES (TYPICAL OF 2)
13. PROVIDE (6) #14 CONTROL WIRES FROM AUX CONTACTS TO EACH ATS TO FACP (1°C)
14. ALTERNATE: PROVIDE FORM 'c' CONTACT AT EACH FEEDER BREAKER WIRED TO MODBUS CONSENTRATOR/POWER METER (TYP AT (1) CB IS SHOWN)
15. PROVIDE 3/4" CONDUIT AND WIRING TO MAIN METER.

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2 3/11/08 CDN. REVISIONS
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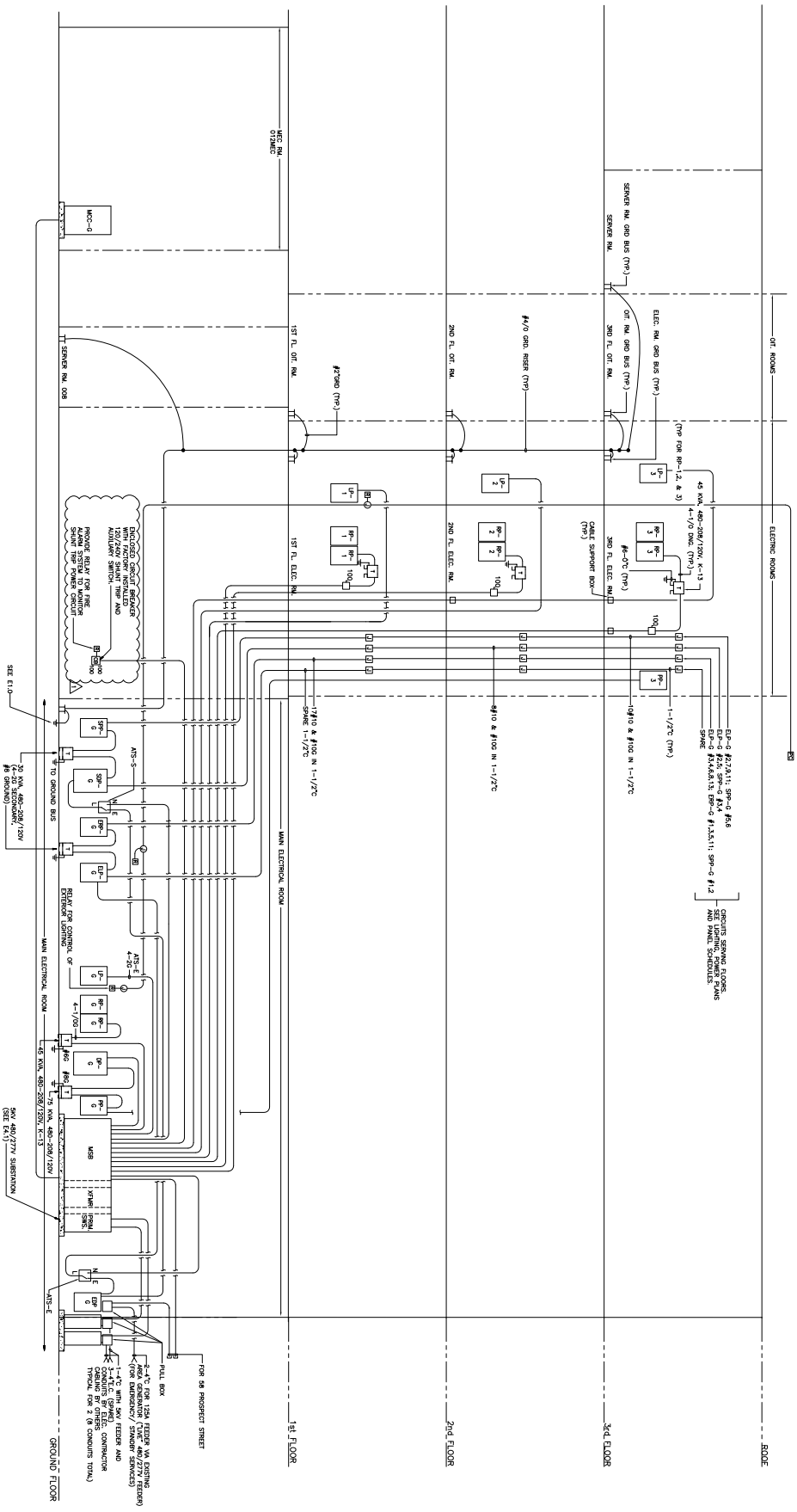
DRAWING TITLE:
ELECTRICAL: SINGLE LINE RISER DIAGRAM

SCALE:
SCALE: NONE

SHEET NUMBER:
E3.1



POWER RISER DIAGRAM

SCALE: NONE

DRAWING TITLE: ELECTRICAL: POWER RISER DIAGRAM

SCALE: NONE

SHEET NUMBER: E3.2

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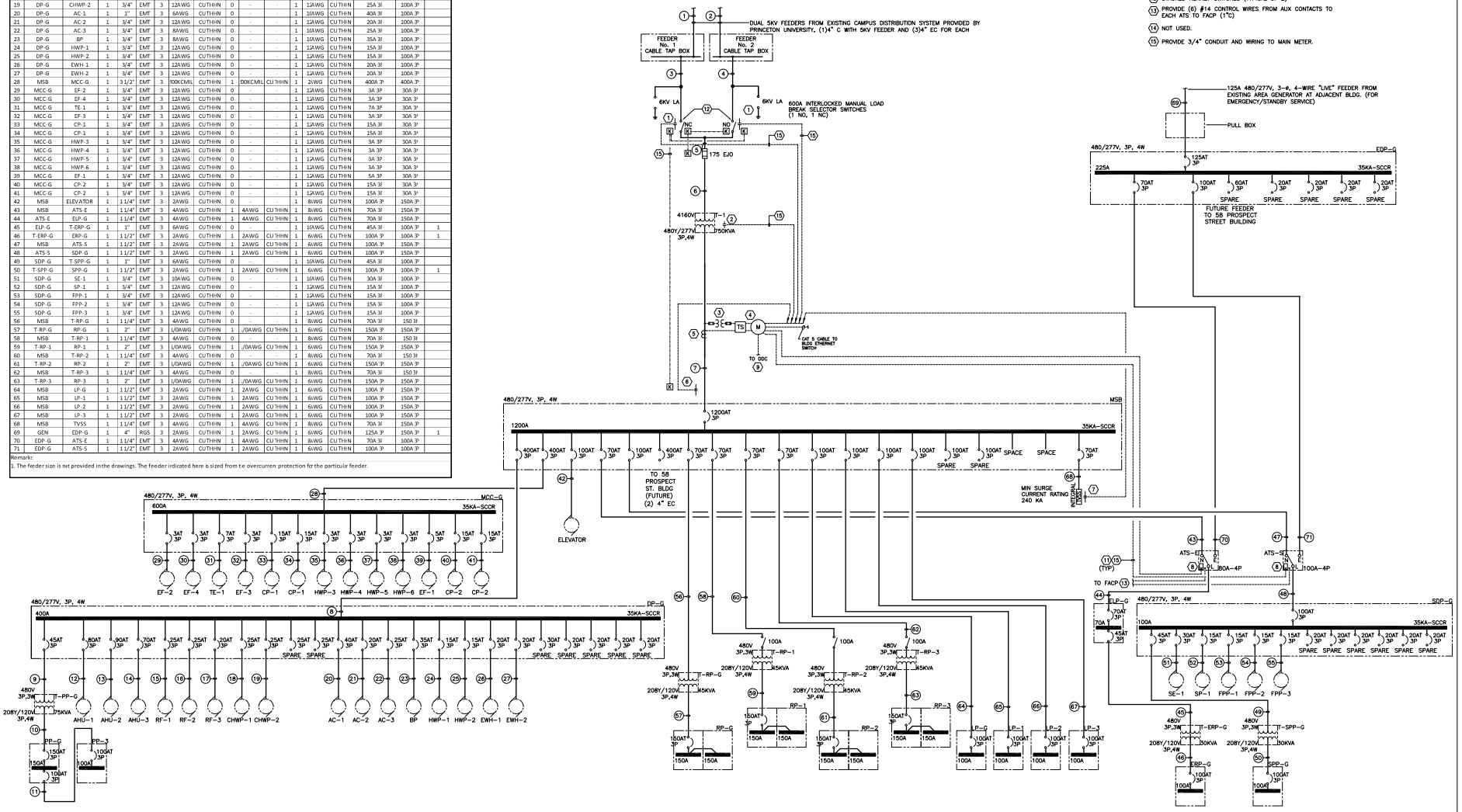
FEEDER SCHEDULE																
				CONDUIT (PERSET)		CONDUCTORS (PER SET)										
						PHASE CONDUCTORS			NEUTRAL CONDUCTORS			GROUND CONDUCTORS				
TAG	FROM	TO	NO. OF SETS	SIZE	TYPE	NO.	SIZE	TYPE	NO.	SIZE	TYPE	NO.	SIZE	TYPE	SIZE OF OVERCURRENT PROTECTION	FRAME OR SWITCH SIZE	REMARKS
1	CAMPUS	TAP BOX 1	1	4"	RGS	3	500KCMIL	CU MV- 105	0	-	-	0	-	-	-	-	
2	CAMPUS	TAP BOX 2	1	4"	RGS	3	500KCMIL	CU MV- 105	0	-	-	0	-	-	-	-	
3	TAP BOX	5KV SWITCH	1	5"	EMT	3	500KCMIL	CU MV- 105	0	-	-	1	1/4AWG	CU THIN	-	-	
4	TAP BOX	5KV SWITCH	1	5"	EMT	3	500KCMIL	CU MV- 105	0	-	-	1	1/4AWG	CU THIN	-	-	
5	SWITCHES	175 EJO FUSE	1	5"	EMT	3	500KCMIL	CU MV- 105	0	-	-	1	1/4AWG	CU THIN	-	-	
6	175 EJO FUSE	T-1	1	5"	EMT	3	500KCMIL	CU MV- 105	0	-	-	1	1/4AWG	CU THIN	175A 3P	-	
7	T-1	MSB	3	3 1/2"	EMT	3	500KCMIL	CU THHN	1	500KCMIL	CU THHN	1	2AWG	CU THIN	1200A 3P	1200A 3P	1
8	MSB	DP-G	1	3 1/2"	EMT	3	500KCMIL	CU THHN	1	500KCMIL	CU THHN	1	2AWG	CU THIN	400A 3P	400A 3P	
9	DP-G	T-PP-G	1	1"	EMT	3	6AWG	CU THHN	0	-	-	1	10AWG	CU THIN	45A 3P	100A 3P	1
10	T-PP-G	PP-G	1	2"	EMT	3	1/0AWG	CU THHN	1	1/0AWG	CU THHN	1	6AWG	CU THIN	150A 3P	150A 3P	1
11	PP-G	PP-3	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	100A 3P	1
12	DP-G	AHU-1	1	1"	EMT	3	6AWG	CU THHN	0	-	-	1	10AWG	CU THIN	80A 3P	100A 3P	
13	DP-G	AHU-2	1	1 1/4"	EMT	3	4AWG	CU THHN	0	-	-	1	8AWG	CU THIN	90A 3P	100A 3P	
14	DP-G	AHU-3	1	1"	EMT	3	6AWG	CU THHN	0	-	-	1	10AWG	CU THIN	70A 3P	100A 3P	
15	DP-G	RF-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	25A 3P	100A 3P	
16	DP-G	RF-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	25A 3P	100A 3P	
17	DP-G	RF-3	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	20A 3P	100A 3P	
18	DP-G	CHWP-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	25A 3P	100A 3P	
19	DP-G	CHWP-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	25A 3P	100A 3P	
20	DP-G	AC-1	1	1"	EMT	3	6AWG	CU THHN	0	-	-	1	10AWG	CU THIN	40A 3P	100A 3P	
21	DP-G	AC-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	20A 3P	100A 3P	
22	DP-G	AC-3	1	3/4"	EMT	3	8AWG	CU THHN	0	-	-	1	10AWG	CU THIN	25A 3P	100A 3P	
23	DP-G	BP	1	3/4"	EMT	3	8AWG	CU THHN	0	-	-	1	10AWG	CU THIN	35A 3P	100A 3P	
24	DP-G	HWP-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	100A 3P	
25	DP-G	HWP-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	100A 3P	
26	DP-G	EWH-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	20A 3P	100A 3P	
27	DP-G	EWH-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	20A 3P	100A 3P	
28	MSB	MCC-G	1	3 1/2"	EMT	3	500KCMIL	CU THHN	1	500KCMIL	CU THHN	1	2AWG	CU THIN	400A 3P	400A 3P	
29	MCC-G	EF-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	3A 3P	30A 3P	
30	MCC-G	EF-4	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	3A 3P	30A 3P	
31	MCC-G	TE-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	7A 3P	30A 3P	
32	MCC-G	EF-3	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	3A 3P	30A 3P	
33	MCC-G	CP-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	30A 3P	
34	MCC-G	CP-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	30A 3P	
35	MCC-G	HWP-3	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	3A 3P	30A 3P	
36	MCC-G	HWP-4	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	3A 3P	30A 3P	
37	MCC-G	HWP-5	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	3A 3P	30A 3P	
38	MCC-G	HWP-6	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	3A 3P	30A 3P	
39	MCC-G	EF-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	5A 3P	30A 3P	
40	MCC-G	CP-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	30A 3P	
41	MCC-G	CP-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	30A 3P	
42	MSB	ELEVATOR	1	1 1/4"	EMT	3	2AWG	CU THHN	0	-	-	1	8AWG	CU THIN	100A 3P	150A 3P	
43	MSB	ATS-E	1	1 1/4"	EMT	3	4AWG	CU THHN	1	4AWG	CU THHN	1	8AWG	CU THIN	70A 3P	150A 3P	
44	ATS-E	ELP-G	1	1 1/4"	EMT	3	4AWG	CU THHN	1	4AWG	CU THHN	1	8AWG	CU THIN	70A 3P	150A 3P	
45	ELP-G	T-ERP-G	1	1"	EMT	3	6AWG	CU THHN	0	-	-	1	10AWG	CU THIN	45A 3P	100A 3P	1
46	T-ERP-G	ERP-G	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	100A 3P	1
47	MSB	ATS-S	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	150A 3P	
48	ATS-S	SDP-G	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	150A 3P	
49	SDP-G	T-SPP-G	1	1"	EMT	3	6AWG	CU THHN	0	-	-	1	10AWG	CU THIN	45A 3P	100A 3P	
50	T-SPP-G	SPP-G	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	100A 3P	1
51	SDP-G	SE-1	1	3/4"	EMT	3	10AWG	CU THHN	0	-	-	1	10AWG	CU THIN	30A 3P	100A 3P	
52	SDP-G	SP-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	100A 3P	
53	SDP-G	FPP-1	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	100A 3P	
54	SDP-G	FPP-2	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	100A 3P	
55	SDP-G	FPP-3	1	3/4"	EMT	3	12AWG	CU THHN	0	-	-	1	12AWG	CU THIN	15A 3P	100A 3P	
56	MSB	T-RP-G	1	1 1/4"	EMT	3	4AWG	CU THHN	0	-	-	1	8AWG	CU THIN	70A 3P	150 3P	
57	T-RP-G	RP-G	1	2"	EMT	3	1/0AWG	CU THHN	1	1/0AWG	CU THHN	1	6AWG	CU THIN	150A 3P	150A 3P	
58	MSB	T-RP-1	1	1 1/4"	EMT	3	4AWG	CU THHN	0	-	-	1	8AWG	CU THIN	70A 3P	150 3P	
59	T-RP-1	RP-1	1	2"	EMT	3	1/0AWG	CU THHN	1	1/0AWG	CU THHN	1	6AWG	CU THIN	150A 3P	150A 3P	
60	MSB	T-RP-2	1	1 1/4"	EMT	3	4AWG	CU THHN	0	-	-	1	8AWG	CU THIN	70A 3P	150 3P	
61	T-RP-2	RP-2	1	2"	EMT	3	1/0AWG	CU THHN	1	1/0AWG	CU THHN	1	6AWG	CU THIN	150A 3P	150A 3P	
62	MSB	T-RP-3	1	1 1/4"	EMT	3	4AWG	CU THHN	0	-	-	1	8AWG	CU THIN	70A 3P	150 3P	
63	T-RP-3	RP-3	1	2"	EMT	3	1/0AWG	CU THHN	1	1/0AWG	CU THHN	1	6AWG	CU THIN	150A 3P	150A 3P	
64	MSB	LP-G	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	150A 3P	
65	MSB	LP-1	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	150A 3P	
66	MSB	LP-2	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	150A 3P	
67	MSB	LP-3	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	150A 3P	
68	MSB	TVSS	1	1 1/4"	EMT	3	4AWG	CU THHN	1	4AWG	CU THHN	1	8AWG	CU THIN	70A 3P	150A 3P	
69	GEN	EDP-G	1	4"	RGS	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	125A 3P	150A 3P	1
70	EDP-G	ATS-E	1	1 1/4"	EMT	3	4AWG	CU THHN	1	4AWG	CU THHN	1	8AWG	CU THIN	70A 3P	100A 3P	
71	EDP-G	ATS-S	1	1 1/2"	EMT	3	2AWG	CU THHN	1	2AWG	CU THHN	1	6AWG	CU THIN	100A 3P	100A 3P	

Remarks:
1. The feeder size is not provided in the drawings. The feeder indicated here is sized from the overcurrent protection for the particular feeder.

METERING SYSTEM NOTES:

1. AUX POSITION SWITCH ON 5KV INTERRUPTER SWITCH. CLOSED WHEN MAIN SWITCH IS CLOSED.
2. GANGED TRANSFORMER ALARM CONTACT. CLOSED ON HIGH TEMP, LOW LEVEL, ETC.
3. (3) VT'S WITH 120 VAC SECONDARIES.
4. POWER MEASUREMENT METER WITH TEST SWITCH. METER ACCEPTS UP TO EIGHT DIGITAL INPUTS (DI).
5. (3) CT'S WITH 5 AMP SECONDARIES AND MULTI-RATIO TAPS ALL WIRED OUT TO ACCESSIBLE TERMINATION BLOCKS.
6. AUX. CONTACT ON POWER CIRCUIT BREAKER. CLOSED WHEN BREAKER IS CLOSED.
7. TVSS ALARM CONTACT. CLOSED WHEN TVSS IN ALARM.
8. ATS WITH MODBUS COMMUNICATION CARD.
9. KWH PULSE OUTPUT TO NEAREST DDC CONTROL CABINET.
10. NOT USED.
11. MODBUS RS-485 WIRING (BELDEN 9841 OR APPROVED EQUAL) (TYPICAL) PROVIDE WIRE AND CONDUIT.
12. STACKED KENNEY SWITCHES (TYPICAL OF 2)
13. PROVIDE (6) #14 CONTROL WIRES FROM AUX CONTACTS TO EACH ATS TO FACP (1"C)
14. NOT USED.
15. PROVIDE 3/4" CONDUIT AND WIRING TO MAIN METER.



SINGLE LINE DIAGRAM
NOT TO SCALE

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SHERRERD HALL: SEAS/ORFE
PRINCETON UNIVERSITY
PRINCETON, NEW JERSEY

JAMIE DEVENGER
AE481W

THESIS
10/30/2009

100% TECH 2

DRAWING TITLE:
ELECTRICAL:
SINGLE LINE DIAGRAM

SCALE: NONE

SHEET NUMBER:
E1.0

[Appendix B] High Intensity Discharge Lamp/Ballast Combination

[Type FE] Lamp: (1) 35W PAR20 MH
Ballast Type: Electronic

PHILIPS

MasterColor CDM 35W/942 Med PAR20 Spot Univ

Keyword search

+ Advanced search

MasterColor CDM 35W/942 Med PAR20 Spot Univ

Lamp Description

Range of compact, high-efficiency, ceramic metal halide reflector lamps with a stable color over lifetime and a crisp, sparkling light.

- Download product data sheet
- Print page

Product specs: + Images: + Family info:

PRODUCT DATA

Product Number	151407
Full product name	MasterColor CDM 35W/942 Med PAR20 Spot Univ
Ordering Code	CDM35 PAR20/M/SP/4K (942)
Pack type	1 Lamp in a Folding Carton
Pieces per Sku	1
Skus/Case	12
Pack UPC	046677151409
EAN2US	
Case Bar Code	50046677151404
Successor Product number	
General Characteristics	
Base	Medium [Single Contact Medium Screw]
Base Information	Nic/Brass [Nickel/Brass Base]
Bulb	PAR20 [PAR 2.5 inch]
Bulb Material	Hard Glass
Bulb Finish	Reflector

Operating Position	Universal [Any or Universal (U)]
Packing Type	1CT [1 Lamp in a Folding Carton]
Packing Configuration	12
RatedAvgLife(See Family Notes)	6000 hr
Feature	FadeBlock™
Ordering Code	CDM35 PAR20/M/SP/4K (942)
Pack UPC	046677151409
Case Bar Code	50046677151404
ANSI Code HID	M130/O
Electrical Characteristics	
Watts	35W
Lamp Voltage	85 V
Light Technical Characteristics	
Beam Description	Spot
Beam Angle	10D
Approx. MBCP	21500 cd
Color Code	942 [CCT of 4200K]
Color Rendering Index	92 Ra8
Color Designation	Cool White
Color Temperature	4100 K
Initial Lumens	1950 Lm
Design Mean Lumens	1650 Lm
Product Dimensions	
Max Overall Length (MOL) - C	3.75 in
Diameter D	2.55 in
Logistic and Packing Data	
Product Number	151407

Revised: 3/5/2009

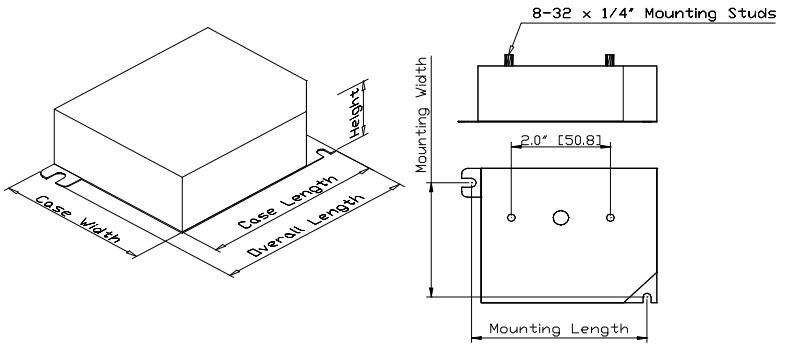
PHILIPS ADVANCE

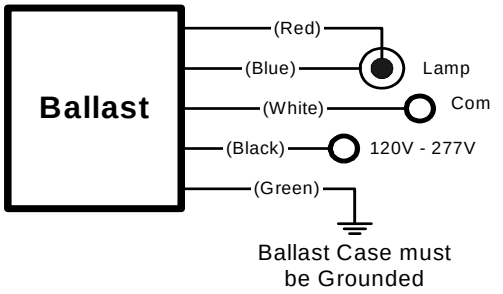
e-Vision® Electronic Ballast for Metal Halide Lamps

Catalog Number: IMH-39-G
For 39W Metal Halide Lamps
ANSI M130
120-277 50/60Hz Electronic
Status: RELEASED

DIMENSIONS AND DATA

Lamp Number	Lamp Watts	Input Volts	Catalong Number*	Line Current (Amps)	Input Power (Watts)	Min Power Factor	Wiring Diag	Fig.	Weight (lb)	Max. Distance to Lamp (ft)
39W Watt Lamp, ANSI Code M130 Minimum Starting Temp -30°C/-20°F										
1	39	120	IMH-39-G-XXX	0.39	46	0.9	3	G	0.9	5
		277		0.18	45					

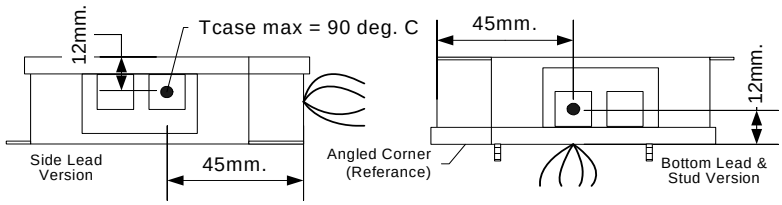




Ballast Case must be Grounded

Wiring Diagram 3

Case Figure	Overall Length	Case Length	Case Width	Height	Mountin Length	Mounting Width
G	97mm [3.8"]	90mm [3.5"]	77mm [3.0"]	30mm [1.2"]	87mm [3.4"]	67mm [2.6"]



Case Temperature Measurement Location

INSTALLATION & APPLICATION NOTES:

1. Maximum allowable case temperature is 90°C. See figure above for measurement location
2. Ignition pulse is 4 kV max
3. All leads are 9 inches long
4. Ballast output will shutdown after 20 minutes if lamp fails to ignite
5. Power must be cycled off – then on, after replacing lamp
6. Connect the red lead to the center terminals of the lamp when using screw base lamps

***Ordering Information**

Order Suffix	Description
-LF	Ballast with side exit leads and mounting feet
-BLS	Ballast with bottom exit leads and mounting studs

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

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