The Barnes Foundation
2025 Benjamin Franklin Parkway, Philadelphia, PA 19130

Technical Report II

Electrical Systems Existing Conditions and Building Load Summary

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Executive Summary

The following report will discuss the design criteria, existing condition, and evaluation of the electrical system for The Barnes Foundation in Philadelphia, PA. In each section of this report an analysis of the electrical load, utility company, emergency power, special occupancies, and various other systems was done with respect to codes established by NEC, IBC, and ASHRAE. The electrical equipment used throughout the building was also studied for performance and efficiency.

Through the comparison of the criteria established and the existing conditions, it was found that The Barnes Foundation's current electrical system is both efficient and reliable. Service entering the site is 480Y/208V and logically steps down with the use of various transformers to supply the correct voltage to the different equipment in the building. The Barnes uses a switchboard and distribution panels to dispense and supply enough power to the nearly 2200 kVA site. Occupancy and daylight sensors are currently in place, as well as a lighting schedule to reduce lighting usage. A building management system is in place to control the various mechanical systems used throughout the building and distribute the energy being gained from the photovoltaic panels located on the roof. From the beginning of design, The Barnes aimed for a LEED Platinum rating, which it achieved, and this is evident in the entire building.

Table of Contents

Building Overview

Building Name
The Barnes Foundation
Philadelphia Campus

Location
2025 Benjamin Franklin Parkway, Philadelphia, PA 19130

Building Occupant Name
The Barnes Foundation

Occupancy or Function Types
Assembly (A-3), Business (B)
Conference Rooms, Auditorium, Lounges, Library

Size (Total square feet)
91,748 GSF

Number of Stories Above Grade / Total Levels
2 Stories above ground | 61' above ground
3 Stories total

Dates of Construction
11/10/2009 – 2/23/2012

Cost Information
Total Cost - $75,890,374

Project Delivery Method
Guaranteed Maximum Price (GMP)

Primary Project Team

Owner
The Barnes Foundation | http://www.barnesfoundation.org/

Architect
Tod Williams Billie Tsien Architects | http://www.twbta.com/

Associate Architect/LEED
Ballinger Architects | http://www.ballinger-ae.com/

Landscape Architect
Olin Partnership | http://www.theolinstudio.com/

MEP Engineer
Altieri Sebor Wieber | http://www.altieriseborwieber.com/

Lighting Designer
Fisher Marantz Stone | http://www.fmsp.com/

Part I - Electrical System Criteria & Scope

Preliminary Electrical Load Calculation

The following table shows the design demand load of the entire facility using the gross square footage found in the "Building Overview" section.

Table 1 | Designed Demand Load

	Lighting	Receptacle	Mechanical	Specialty
LPD	1 VA/ft2	1 VA/ft2	4 VA/ft2	1 VA/ft2
Demand Factor	125%	First 10 kVA at 100%; Remainder at 50%	100%	100%
Allowable Load	114.69 kVA	50.87 kVA	366.99 kVA	91.75 kVA
Total Demand Load	**624.30 kVA**			

Local Utility Company

The Barnes Foundation is served by PECO (www.peco.com) is a subsidiary of the Exelon Corporation. PECO services southeastern Pennsylvania (primarily Bucks, Montgomery, Chester, Delaware, and Philadelphia Counties) and is the largest electric and natural gas utility provider in Pennsylvania.

Preliminary Utility Rate Schedule

Rate-HT High Tension Power

Availability

Untransformed service from the Company's standard high-tension lines, where the customer installs, owns, and maintains, any transforming, switching, and other receiving equipment required

Current Characteristics

Standard high-tension service.

Monthly Rate Table

Fixed Distribution Service Charge | $298.92
Variable Distribution Service Charge
| $3.55 per kW of billing demand
| 0.15¢ per kWh for all kWh

Energy Efficiency Charge

$0.79 per kW of Peak Load Contribution

Determination of Billing Demand

The billing demand will be computed to the nearest kilowatt and will never be less than the measured demand, adjusted for power factor in accordance with the Rules and Regulations, nor less than 25 kilowatts. Additionally, the billing demand will not be less than 40% of the maximum demand specified in the contract. The 25 kW minimum shall apply to the Energy Supply Charge and the Transmission Supply Charge.

Minimum Charge

The monthly minimum charge shall be the Fixed Distribution Service Charge, plus the charge per kW component of the Variable Distribution Service Charge, and modify less the high voltage discount where applicable plus in the case of Procurement Class 4 customers, charges assessed on PJM's reliability pricing model.

Preliminary Building Utilization Voltage

The preliminary building utilization voltage is 480/277V, 3PH. This allows for the following breakdown of voltages.

Lighting	|	120V
Receptacle	|	120V
Mechanical	|	480V
Special Equipment		
Elevator	|	480V
Audio/Visual	|	120V
IT	|	120V

Emergency Power Requirements

A 1000 kVA generator running at 480Y/277V should be used to supply emergency power to the facility. The generator was sized by summing the total kVA from all of the emergency panelboards. The following are IBC requirements for mergency power.

2702.2.1 Group A Occupancies
Emergency power shall be provided for emergency voice/alarm communication systems in Group A occupancies in accordance with Section 907.5.2.2.4.

2702.2.2 Smoke Control Systems
Standby power shall be provided for smoke control systems in accordance with Section 909.11.

2702.2.3 Exit Signs
Emergency power shall be provided for exit signs in accordance with Section 1011.5.3.

2702.2.4 Means of Egress Illumination
Emergency power shall be provided for means of egress illumination in accordance with Section 1006.3.

2702.2.5 Accessible Means of Egress Elevators
Standby power shall be provided for elevators that are part of an accessible means of egress in accordance with Section 1007.4.

2702.2.6 Accessible Means of Egress Platform Lifts
Standby power in accordance with this section or ASME A 18.1 shall be provided for platform lifts that are part of an accessible means of egress in accordance with Section 1007.5.

2702.2.10 Hazardous Materials
Emergency or standby power shall be provided in occupancies with hazardous materials in accordance with Section 414.5.4.

2702.2.19 Elevators
Standby power for elevators shall be provided as set forth in Sections 3003.1, 3007.7 and 3008.15.

2702.2.20 Smokeproof Enclosures
Standby power shall be provided for smokeproof enclosures as required by Section 909.20.6.2.

Special Occupancy Requirements

In accordance with National Electric Code 2011 Chapter 5, Article 518, The Barnes Foundation falls under the Assembly Occupancies Hazardous Locations.

Priority Assessment

High	Medium	Low
Reliability	Power Quality	Low First Cost
Redundancy	Flexibility	
Low Life Cycle Cost		

Optional Back-Up Power

An uniterruptible power system will be put in place to handle all telecommunication, data, and computers in a case of emergency. The UPS should be sized to roughly 30 kVA to be capable of handling the different systems specified plus any unforseen load that UPS may be connected to. Furthermore, designated critical operation areas (DCOAs) will be established for the museum, special exhibit area, and conservation lab to maintain humidity control and security in the spaces. These will not require a separate power source, rather it will require that the generator be able to handle the necessary load to maintain typical conditions in the space.

Special/Communication Systems

Telephone/Data
Fire Alarm
Access Control
Intrusion Detection
Video Surveillance

Fire Alarm Requirements

907.2.1 Group A.

A manual fire alarm system that activates the occupant notification system in accordance with Section 907.5 shall be installed in Group A occupancies where the occupant load due to the assembly occupancy is 300 or more. Group A occupancies not separated from one another in accordance with Section 707.3.9 shall be considered as a single occupancy for the purposes of applying this section. Portions of Group E occupancies occupied for assembly purposes shall be provided with a fire alarm system as required for the

Group E occupancy.

Manual fire alarm boxes are not required where the building is equipped throughout with an *automatic sprinkler system* installed in accordance with Section 903.3.1.1 and the occupant notification appliances will activate throughout the notification zones upon sprinkler waterflow.

907.2.1.1 System initiation in Group A occupancies with an occupant load of 1,000 or more.
Activation of the fire alarm in Group A occupancies with an *occupant load* of 1,000 or more shall initiate a signal using an emergency voice/alarm communications system in accordance with Section 907.5.2.2.

Where *approved*, the prerecorded announcement is allowed to be manually deactivated for a period of time, not to exceed 3 minutes, for the sole purpose of allowing a live voice announcement from an *approved*, *constantly attended location*.

907.2.2 Group B.
A manual fire alarm system shall be installed in Group B occupancies where one of the following conditions exists:

1. The combined Group B *occupant load* of all floors is 500 or more.

2. The Group B *occupant load* is more than 100 persons above or below the lowest level of exit discharge.

3. The *fire area* contains an ambulatory care facility.

Manual fire alarm boxes are not required where the building is equipped throughout with an *automatic sprinkler system* installed in accordance with Section 903.3.1.1 and the occupant notification appliances will activate throughout the notification zones upon sprinkler waterflow.

907.5 Occupant notification systems.
A fire alarm system shall annunciate at the fire alarm control unit and shall initiate occupant notification upon activation, in accordance with Sections 907.5.1 through 907.5.2.3.4. Where a fire alarm system is required by another section of this code, it shall be activated by:

1. Automatic fire detectors.

2. *Automatic sprinkler system* waterflow devices.

3. Manual fire alarm boxes.

4. Automatic fire-extinguishing systems.

Where notification systems are allowed elsewhere in Section 907 to annunciate at a *constantly attended location*.

Major Equipment

The major electrical equipment needed for this building would be a switchgear, distribution panels, panelboards, transformers, metering devices, generator, and UPS. Assuming that 2% of the total building square footage will be set aside for electric equipment, there should be approximately 1,835 ft^2 of electrical space. However, since some of the spaces within the building are very spacious or have minimal electrical needs, this value will be reduced to 1,500 ft^2.

In acordance with IBC Table 706.4, Buildings of types A and B with Type II construction shall be permitted a 2-hour fire-resistance rating. However, since a portion of the facility houses delicate pieces of art, a 3-hour fire-resistance rating shall be used for those sections of the building.

The following discusses the sizes and illumination required by the IBC for means of egress.

1005.3.1 Stairways.
The capacity, in inches (mm), of *means of egress stairways* shall be calculated by multiplying the *occupant load* served by such *stairway* by a *means of egress* capacity factor of 0.3 inch (7.6 mm) per occupant. Where *stairways* serve more than one story, only the *occupant load* of each story considered individually shall be used in calculating the required capacity of the *stairways* serving that story.

For other than Group H and I-2 occupancies, the capacity, in inches (mm), of *means of egress stairways* shall be calculated by multiplying the *occupant load* served by such *stairway* by a *means of egress* capacity factor of 0.2 inch (5.1 mm) per occupant in buildings equipped throughout with an *automatic sprinkler system* installed in accordance with Section 903.3.1.1 or 903.3.1.2 and an *emergency voice/alarm communication system* in accordance with Section 907.5.2.2.

1005.3.2 Other egress components.
The capacity, in inches (mm), of *means of egress* components other than *stairways* shall be calculated by multiplying the *occupant load* served by such component by a *means of egress* capacity factor of 0.2 inch (5.1 mm) per occupant.

For other than Group H and I-2 occupancies, the capacity, in inches (mm), of *means of egress* components other than *stairways* shall be calculated by multiplying the *occupant load* served by such component by a *means of egress* capacity factor of 0.15 inch (3.8 mm) per occupant in buildings equipped throughout with an *automatic sprinkler system* installed in accordance with Section 903.3.1.1 or 903.3.1.2 and an *emergency voice/alarm communication system* in accordance with Section 907.5.2.2.

1005.7.1 Doors.
Doors, when fully opened, shall not reduce the required width by more than 7 inches (178 mm). Doors in any position shall not reduce the required width by more than one-half.

1. Surface-mounted latch release hardware shall be exempt from inclusion in the 7-inch maximum (178 mm) encroachment where:
1.1. The hardware is mounted to the side of the door facing away from the adjacent wall where the door is in the open position; and
1.2. The hardware is mounted not less than 34 inches (865 mm) nor more than 48 inches (1219 mm) above the finished floor.
2. The restrictions on door swing shall not apply to doors within individual *dwelling units* and *sleeping units* of Group R-2 occupancies and *dwelling units* of Group R-3 occupancies.

1006.2 Illumination level.
The *means of egress* illumination level shall not be less than 1 footcandle (11 lux) at the walking surface.

For auditoriums, theaters, concert or opera halls and similar assembly occupancies, the illumination at the walking surface is permitted to be reduced during performances to not less than 0.2 footcandle (2.15 lux), provided that the required illumination is automatically restored upon activation of a premises' fire alarm system where such system is provided.

1006.3 Emergency power for illumination.
The power supply for *means of egress* illumination shall normally be provided by the premises' electrical supply.

In the event of power supply failure, an emergency electrical system shall automatically illuminate all of the following areas:

1. *Aisles* and unenclosed egress stairways in rooms and spaces that require two or more *means of egress*.

2. *Corridors*, *interior exit stairways* and *ramps* and *exit passageways* in buildings required to have two or more *exits*.

3. Exterior egress components at other than their levels of *exit discharge* until *exit discharge* is accomplished for buildings required to have two or more *exits*.

4. Interior *exit discharge* elements, as permitted in Section 1027.1, in buildings required to have two or more *exits*.

5. Exterior landings as required by Section 1008.1.6 for *exit discharge* doorways in buildings required to have two or more *exits*.

The emergency power system shall provide power for a duration of not less than 90 minutes and shall consist of storage batteries, unit equipment or an on-site generator. The installation of the emergency power system shall be in accordance with Section 2702.

1006.3.1 Illumination level under emergency power.
Emergency lighting facilities shall be arranged to provide initial illumination that is at least an average of 1 footcandle (11 lux) and a minimum at any point of 0.1 footcandle (1 lux) measured along the path of egress at floor level. Illumination levels shall be permitted to decline to 0.6 footcandle (6 lux) average and a minimum at any point of 0.06 footcandle (0.6 lux) at the end of the emergency lighting time duration. A maximum-to-minimum illumination uniformity ratio of 40 to 1 shall not be exceeded.

Part II - Electrical System As Designed

Actual Connected Building Load

The following is the calculated connected load of The Barnes separated into lighting, receptacle, mechanical, and specialty categories.

Table 2 | Actual Connected Load

Panel	Lighting	Receptacle	Mechanical	Specialty
MDP	-	-	285.9	
SDP-N1	-	-	-	64.08
SDP-N2	-	-	-	122.4
SDP-N3	-	-	-	68.27
RP-AT1	-	-	-	54.1
RP-AT2	-	-	-	24.5
PP-S	-	-	-	53.29
PP-L1	-	-	97.02	7.2
PP-L2	-	-	36.57	-
RP-C	-	10.7	9.26	41.05
RP-CA	0.5	1.8	8.2	5.75
RP-LS1	3.13	11.81	1.45	23.78
RP-LS2	-	1.7	2.59	-
RP-LS3	-	-	-	-
RP-LN1	1	12.8	2.55	13.49
RP-LN2	3.98	3.56		
RP-LN3	4.57	5.58	1	7.8
RP-1N1	-	11.74	3.98	5.33
RP-2N1	14.96	13.68	1.76	0.72
RP-1S	8.61	6.83	-	10.66
RP-1N2	5.18	13.86	-	0.1
RP-1N3	-	-	-	-
RP-2L	-	6.48	-	18.9
RP-2N2	17.66	10.44	-	-
RP-2S	6.71	9.54	-	3.35
Total	66.3	120.52	450.28	524.77

Panel	Lighting	Receptacle	Mechanical	Specialty
EDP-S	-	-	-	360.8
ERL-LN	1.4	-	-	5.87
ERL-1N	5.38	-	-	4.67
ERL-1S	6.28	-	-	-
ERL-2N	5.94	-	-	-
ELEV-1	0.3	0.4	0.5	2.4
ELEV-2	0.3	0.4	0.5	8.4
ELEV-3	0.3	0.4	-	3.27
EPP-LN1	-	-	118.83	36.84
EPP-LN2	-	-	19.14	19.02
EPP-LN3	-	-	2.52	80.2
EPP-CT	-	-	108.93	6.3
ERP-CT	0.8	1.4	3.8	0.5
ERP-LN2	1	7.82	2.5	7.62
ERP-LN3	-	28.64	1.42	-
ERP-LN4	-	6.12	6.99	3.4
EPP-2S	-	-	44.64	-
ERP-2S	-	1.98	2.1	25
ERP-GH	0.2	1.28	8.81	1
ERP-LN1	2	3.08	3.16	28.22
Total	23.9	51.52	323.84	593.51

Building Connected Load	2154.64 kVA

Utility Company Rate Schedule

Availability

Untransformed service from the Company's standard high-tension lines, where the customer installs, owns, and maintains, any transforming, switching, and other receiving equipment required

Current Characteristics

Standard high-tension service.

Monthly Rate Table

Fixed Distribution Service Charge | $298.92
Variable Distribution Service Charge
| $3.55 per kW of billing demand

| 0.15¢ per kWh for all kWh

Energy Efficiency Charge

$0.79 per kW of Peak Load Contribution

Determination of Billing Demand

The billing demand will be computed to the nearest kilowatt and will never be less than the measured demand, adjusted for power factor in accordance with the Rules and Regulations, nor less than 25 kilowatts. Additionally, the billing demand will not be less than 40% of the maximum demand specified in the contract. The 25 kW minimum shall apply to the Energy Supply Charge and the Transmission Supply Charge.

Minimum Charge

The monthly minimum charge shall be the Fixed Distribution Service Charge, plus the charge per kW component of the Variable Distribution Service Charge, and modify less the high voltage discount where applicable plus in the case of Procurement Class 4 customers, charges assessed on PJM's reliability pricing model.

Utility Company Building Utilization Voltage

The preliminary building utilization voltage is 480/277V, 3PH. This allows for the following breakdown of voltages.

Lighting	|	120V
Receptacle	|	120V
Mechanical	|	480V
Special Equipment		
Elevator	|	480V
Audio/Visual	|	120V
IT	|	120V
Water Features	|	208V
Misc. Tools	|	208V

Emergency Power System

The emergency power of the building is powered by a 400 kW/500 kVA diesel generator. Located outside at the northwest corner of the site, the generator runs at 480Y/277V, 3PH, 4W, and is placed inside a sound attenuated weatherproof enclosure. There is a load bank and a 1700 gallon sub-base day tank that will be able to provide power to the facility for a minimum of 63 hours. Two circuit breakers (225A and 600A) are mounted to the generator.

When emergency power is needed, the generator sends power through two separate automatic transfer switches, one 225A and the other 1200A. The former line then runs through a step-down transformer to reach 208Y/120V and then enters a distribution panel. This distribution panel supplies power to emergency lighting, fire alarm system, and sprinkler air compressor. The latter line goes straight to a separate distribution panel where it supplies power to the elevators, a chiller, and three 480Y/277V panels. These panels supply power to cooling towers, heaters, air handling units, blower coil units, pumps, and fans. These three panels are each connected to step-down transformers to reach 208Y/120V and lead to more panels. These remaining panels supply power to security, receptacles, shade controls, fan coil units, and electric finned-tube radiation units.

A building management system (BMS) is integrated into the building. The BMS will choose selective loads connected to the emergency panels to power, more specifically mechanical equipment. The direct digital control will then prioritize which mechanical systems to operate based on outdoor conditions and available power. Top priority is given to gallery and conservation areas of the facility to maintain typical space conditions.

Special Occupancy Requirements

In accordance with National Electric Code 2011 Chapter 5, Article 518, The Barnes Foundation falls under the Assembly Occupancies Hazardous Locations.

Special Equipment

In accordance with the National Electric Code, Chapter 6, the following special equipment will be used in the facility.

600 | Electric Signs and Outline Lighting
605 | Office Furnishings (Consisting of Lighting Accessories and Wired Partitions)
620 | Elevators
640 | Audio Signal Processing, Amplification, and Reproduction Equipment
660 | X-Ray Equipment
665 | Induction and Dielectric Heating Equipment
675 | Electrically Driven or Controlled Irrigation Machines
680 | Fountains
690 | Solar Photovoltaic (PV) Systems
695 | Fire Pumps

Transformers

The following table describes the various transformers used throughout the site.

Table 3 | Building Transformers

Transformer	Primary Voltage	Secondary Voltage	Size (kVA)	Mounting
PP&L	13.2 kV 3PH, 3W	480Y/277V 3PH, 4W	-	Pad
XF-AUD	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	75	DDNM Isolator
XF-N1	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	225	DDNM Isolator
XF-N2	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	225	DDNM Isolator
XF-N3	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	225	DDNM Isolator
XF-C	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	75	DDNM Isolator
XF-S	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	75	DDNM Isolator
EXF-L	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	112.5	DDNM Isolator
EXF-2S	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	75	DDNM Isolator
EXF-LN1	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	112.5	DDNM Isolator
EXF-LN2	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	30	DDNM Isolator
EXF-CT	480Y/277V 3PH, 4W	208Y/120V 3PH, 4W	15	DDNM Isolator

Panelboards

The following table desscribes the switchboard, distribution panel, and panelboard used throughout the site.

Table 4 | Building Power Distribution

Panel	Voltage	Main Size	Main Type	Location
MDP	480Y/277V 3PH, 4W	2500	MCB	048
SDP-N1	208Y/120V 3PH, 4W	800	MCB	048
SDP-N2	208Y/120V 3PH, 4W	800	MCB	048
SDP-N3	208Y/120V 3PH, 4W	800	MCB	048
PP-AUD	208Y/120V 3PH, 4W	225	MCB	048
RP-AT1	208Y/120V 3PH, 4W	225	MCB	020
RP-AT2	208Y/120V 3PH, 4W	150	MCB	020
PP-S	208Y/120V 3PH, 4W	225	MCB	048
PP-L1 Section #1	480Y/277V 3PH, 4W	400	MCB	048
PP-L1 Section #2	480Y/277V 3PH, 4W	400	MLO	048
PP-L2	480Y/277V 3PH, 4W	100	MCB	006
RP-C	208Y/120V 3PH, 4W	225	MCB	113
RP-CA	208Y/120V 3PH, 4W	100	MCB	182
RP-LS1	208Y/120V 3PH, 4W	225	MCB	060
RP-LS2	208Y/120V 3PH, 4W	100	MCB	060
RP-LS3	208Y/120V 3PH, 4W	100	MCB	060

Panel	Voltage	Main Size	Main Type	Location
RP-LN1	208Y/120V 3PH, 4W	225	MCB	048
RP-LN2	208Y/120V 3PH, 4W	150	MCB	041
RP-LN3	208Y/120V 3PH, 4W	150	MCB	006
RP-1N1 Section #1	208Y/120V 3PH, 4W	225	MCB	116
RP-1N1 Section #2	208Y/120V 3PH, 4W	225	MLO	116
RP-2N1 Section #1	208Y/120V 3PH, 4W	225	MCB	230
RP-2N1 Section #2	208Y/120V 3PH, 4W	225	MLO	230
RP-1S	208Y/120V 3PH, 4W	150	MCB	167
RP-1N2	208Y/120V 3PH, 4W	150	MCB	103
RP-1N3	208Y/120V 3PH, 4W	100	MCB	103
RP-2L	208Y/120V 3PH, 4W	150	MCB	234
RP-2N2 Section #1	208Y/120V 3PH, 4W	225	MCB	214
RP-2N2 Section #2	208Y/120V 3PH, 4W	225	MLO	214
RP-2S	208Y/120V 3PH, 4W	150	MCB	267

Panel	Voltage	Main Size	Main Type	Location
EPP-L	208Y/120V 3PH, 4W	400	MCB	050
EDP-S	480Y/277V 3PH, 4W	1200	MCB	050
ERL-LN	208Y/120V 3PH, 4W	100	MCB	041
ERL-1N	208Y/120V 3PH, 4W	100	MCB	116
ERL-1S	208Y/120V 3PH, 4W	100	MCB	167
ERL-2N	208Y/120V 3PH, 4W	100	MCB	214
ELEV-1	208Y/120V 3PH, 4W	60	MCB	002
ELEV-2	208Y/120V 3PH, 4W	100	MCB	040
ELEV-3	208Y/120V 3PH, 4W	60	MCB	056
EPP-LN1 Section #1	480Y/277V 3PH, 4W	600	MCB	050
EPP-LN1 Section #2	480Y/277V 3PH, 4W	600	MLO	050
EPP-LN2	480Y/277V 3PH, 4W	150	MCB	006
EPP-LN3	480Y/277V 3PH, 4W	150	MCB	052
EPP-CT	480Y/277V 3PH, 4W	225	MCB	Service Yard
ERP-CT	208Y/120V 3PH, 4W	60	MCB	Service Yard
ERP-LN2	208Y/120V 3PH, 4W	100	MCB	006
ERP-LN3	208Y/120V 3PH, 4W	150	MCB	049
ERP-LN4	208Y/120V 3PH, 4W	100	MCB	035
EPP-2S	208Y/120V 3PH, 4W	225	MCB	267
ERP-2S	208Y/120V 3PH, 4W	100	MCB	267
ERP-GH	208Y/120V 3PH, 4W	60	MCB	Guard House
ERP-LN1 Section #1	208Y/120V 3PH, 4W	400	MCB	050
ERP-LN1 Section #2	208Y/120V 3PH, 4W	400	MLO	050

Main Risers & Feeders

Since The Barnes Foundation is not considered a high-rise building, wire & conduit is used rather than bus duct. The following wire type are used within the facility.

Metal Clad Cable (MC)

1. Limited to six (6) foot fixture whips.
2. Lighting and appliance branch circuitry concealed in dry wall partitions and accessible voids of suspended ceilings and concealed spaces.
3. Except equipment feeders and homeruns to overcurrent devices which shall be EMT and wire.

Type RHH in Conduit – 2 Hour Rated

1. Exposed emergency feeders and circuits where specifically indicated on drawings.

Conductors

The building uses copper conductors of the following types.

THHN/THWN-2 (solid or concentric stranded)	|	14 – 10 AWG
THHN/THWN-2 (concentric stranded)	|	8 – 1 AWG
XHHW-2	|	1/0 AWG and larger

Conduit

Threaded Rigid Steel Conduit (RSC)

1. Elevator machine rooms, pits & shafts.
2. Exposed outdoors, roofs, stub-ups, or penetrations through concrete slabs or equipment pads.
3. Circuits above 600 volts.

Electrical Metallic Conduit (EMT)

1. Interior, dry locations for: switchboard, panelboard feeders.
2. Branch feeders, lighting and appliance circuitry.
3. Homeruns to overcurrent protection device.
4. Fire alarm.
5. Telecommunications .

Rigid Non-Metallic Conduit (RNC)

1. Below grade, below slab – Schedule 40
2. Outdoors where exposed to physical damage and in corrosive locations where shown on drawings – Schedule 80
3. Encased in concrete, concrete ductbanks -Type EB (Encasement Burial).

Flexible Metal Conduit (FMC)

1. Final connections minimum 18 inches and less than six (6) feet only for lighting and appliance branch circuitry in accessible voids of suspended ceilings
2. Final connections minimum 18 inches and less than three (3) feet to motors in mechanical rooms
3. Other interior dry locations, or where located in plenums or other spaces used for environmental air.

Liquidtight Flexible Metal Conduit (LFMC)

1. Final connections minimum 18 inches and less than three (3) feet only for lighting and appliance and motor branch circuitry in exposed wet or damp locations.
2. Do not use in plenums or other spaces used for environmental air.

Faceplate Type

The following descriptions are consistent for all faceplates used. For more information on the devices the faceplate is attached to please refer to the "Wiring Device" section.

Interior Faceplates

.040" Type 302/304 stainless steel with brushed finish, Decora-style

Exterior Faceplates

Heavy duty die-cast zinc with spring loaded lift cover, molded nylon Decora-style

Wiring Devices

Switches

Single Pole, 3-way & 4-way Switch

Premium specification grade, 120V, 20A

Key Switch

Industrial grade, NEMA WD1, 120/277V, 20A

3-way Dimmer Control

1000W rated Lutron Maestro, Decora-style

Sensors

Occupancy Sensor

PIR/Ultrasonic or PIR/Microphonic

Receptacles

Typical Recptacle

Premium specification grade, NEMA 5-20R, 125V, 20A

Ground Fault Interrupting (GFI)

NEMA 5-20R, 125V, 20A with 20A feed-through rating

Isolated-Ground (IG)

NEMA 5-20R, insulating barrier between the grounding screw and the mounting cap

Clock Outlet

Stainless steel plate, heavy duty, NEMA 5-15R, 125V, 15A

Motor Starters

The following motor starters are used throughout the facility.

Manual starters are used for single-phase motors that are not interlocked with other equipment.

Magnetic starters are used for three-phase motors of ½ horsepower or larger.

Closed transition, Reduced Voltage autotransformer starters with integral motor circuit protector are used for NEMA size 4 and larger

Variable Frequency Drives provide stepless speed control of standard NEMA Design B squirrel cage induction motors, without motor derating.

UPS Systems

Although not specified in the design drawings, there are most likely rack-mounted UPS's on each of the six racks in the main data and telecom room. With the assumption that each UPS will be rated for 6.25 kVA there is a total of 31.25 kVA supplied. There is also future space for six more racks.

Optional Back-Up Power

Existing electrical drawings show no additional optional back-up power other than the generator.

Special/Communications Systems

Telephone/Data

The main Telecom room is located in the lower level while there is a secondary IT/Comm room located on the second floor. These rooms control the data necessary for the offices on the lower level and second floor, as well as the classrooms located in the museum portion of The Barnes.

Fire Alarm

There are sprinklers throughout the entire facility in case of a fire. Smoke detectors and beam detectors are both used to sense smoke in the various spaces. Speaker/Strobes and some strobe lights are used to alert occupants to any fire related danger in the building. The Fire Alarm Control Panel is located on the first floor in the security office.

Access Control / Intrusion Detection

The Barnes Foundation requires card access to unlock the facility; however, during normal opperating hours the facility is open. Card access is then used to control entrances to back-of-house areas, office areas, and lab areas. When there is not a special exhibit in place, card access is also required to enter the special exhibit area.

Video Surveillance

CCTV cameras are used throughout The Barnes to ensure there are no unwanted guests and that all of the artwork remains safe and secure. Security guards are located throughout the facility during operation hours to ensure optimal safety.

Lighting Control System

An ETC dimming system is used throughout the building. This system is then controlled through Paradigm (designed by ETC) and Light Designer. These programs allow for there to be a base lighting schedule associated with the different spaces on the building; although, this base schedule can be overridden if there is a special event occuring in one of the spaces. Depending on the room, some spaces may have fully addressable fixtures, while other spaces may only have zones to control.

Electrical & Telecommunications System Space

The combined floor space of all electrical and communication rooms is approximately 1,501 ft^2; this accounts for 1.6% of the total building square footage. A further breakdown of spaces follows.

	Total Square Footage	Percent of Building
Electrical Rooms	1,210	1.3%
Communucation Rooms	290.5	0.3%

Energy Reduction Methods

The Barnes Foundation has a daylight control system throughout the building. This system is able to analyze daylight levels using photosensors, be programmed to remember specific calendar events, and use an astronomic time clock. The time clock is also used to control the shading system to limit the amount of direct sunlight penetrating the space. The daylighting system uses an open loop solar adaptive algorithm. Low transmission glazing on the windows prevents UV-radiation from entering the building while also reducing the electrical usage of lighting.

Furthermore, a photovoltaic array is located on top of the light box to receive the optimal amount of light on the site and produce supplemental energy for the facility.

Upon completion, The Barnes Foundation received a LEED Platinum Certification; the first art educational facility to do so.

Part III - Evaluation of Criteria & Current Design

Building Electrical Loads

What should first be made clear is that the designed load in Part I is a demand load and the actual load calculated in Part II is a connected load.

	Type of Load	Building Load (kVA)
Criteria	Demand	624.30
Actual	Connected	2154.64

The connected load is calculated without taking into account the different seasons the building will experience. Considering this, portions of the mechanical equipment will not be used during some parts of the year, thus reducing the total load of the building. This makes the designed demand load very reasonable to what the actual demand load would result as.

Utility Rate Schedule

The current rate schedule is appropriate for the building. The only other option to first consider is Rate-GS General Service. However, the follow is stated at the beginning of the rate.

"For service configuration that are nominally 277/480 volts, 3 phase, 4 wires and capacity exceeds either 750 kVA for traansformers located inside the building or 1,500 kVA for transformers located outside the building, the only rate option available to the customer will be Rate HT."

Building Utilization Voltage

The voltages that will be utilized within the building were consistent between the criteria and the actual facility. The only additions were the special equipment located within the building. I would not suggest any changes to the current system.

Electrical Equipment

It was found that slightly over 1,500 ft^2 of the building was used for electrical and telecommunication space and the design criteria for the amount of space allotted was set at 1,500 ft^2. The Barnes Foundation efficiently maximizes the electrical space to include nearly all electrical equipment. There are a few panelboards that can be found in other spaces, such as mechanical rooms, the guard house, or the café, but these panels are justified to be in the locations that the serve power to rather than in an electrical closet.

There is large room for flexibility in the space already due to panelboards already in place. There are enough non – emergency spare circuits throughout the faciltiy for five panelboards, besides more emergency and non-emergency spare circuits scattered throughout the remaining panels. Furthermore, multiple variable frequency drives used throughout the building help control the reliability of the electrical equipment.

Emergency Power System

With the use of the selective load building management system, the 400 kW/500 kVA generator is able to provide adequate power to the critical operations of the building and meets the code requirements of the IBC. However, in further study of the emergency panels, there is a total of 993 kVA connected.

Connected Load (kVA)	Loads

EPP-L	47	Lighting, Fire Alarm, Sprinklers
EDP-S	946	Mechanical Equipment

As mentioned in Part II, the BMS is capable of analyzing which spaces are in critical need of mechanical systems and supply power to them; but this is partially on an available power basis. With nearly twice the amount of load connected to the emergency panels as the generator can handle, a larger generator should be put in place to handle more of the interior spaces during critical times. While this will most likely result in the need to expand the service yard to make room for a more powerful generator, it will decrease the risk of running out of available emergency power in the facility.

Optional Back-Up Power

Since there is space in the main data and telecom room for more racks it is more beneficial to have individual rack-mounted UPS's for the building. This is because if a singular UPS was placed within the building it may not be capable of handling any future loads. The use of individual UPS's allows for flexibilty and expansion within the system. Furthermore, selective loading allows for designated critical operation areas, such as the gallery and conservation lab, to take precedence in emergency situations.

Potential Control Systems Integration

The building management system allows a user to observe data coming from and control the different mechanical systems throughout the facility. This then combines with the emergency power system to control the crucial systems of the building during power outtages. There is also an EFT dimming system that controls the lighting throughout The Barnes.

Further system integration can be found with an Energy Managaement System (EMS). This type of system monitors the energy usage of the building and the exterior conditions. With this data it begins to create optimized energy performance between the different building systems.

Integrated daylight controls can also be added; however, these will be further discussed in the "Energy Reduction Strategies" Section.

Energy Reduction Strategies

The Barnes Foundation currently reduces energy costs through the use of lighting controls, occupancy sensors, and a photovoltaic array on a portion of the roof to collect sunlight and use that energy within the facility. Within the galleries, daylight sensors are placed to control shades that prevent excess amount of light to enter the galleries and block direct sunlight from hitting the artwork.

These daylight senors could also be placed in other locations of the building to balance electric illumination levels with daily exterior conditions to create a further reduction of energy. The use of dimming ballasts will be required though in any location that daylight sensors are placed. Overall this will not effect the LEED Certification of The Barnes Foundation since the facility is already rated LEED Platinum; however, energy reduction will always benefit the building.

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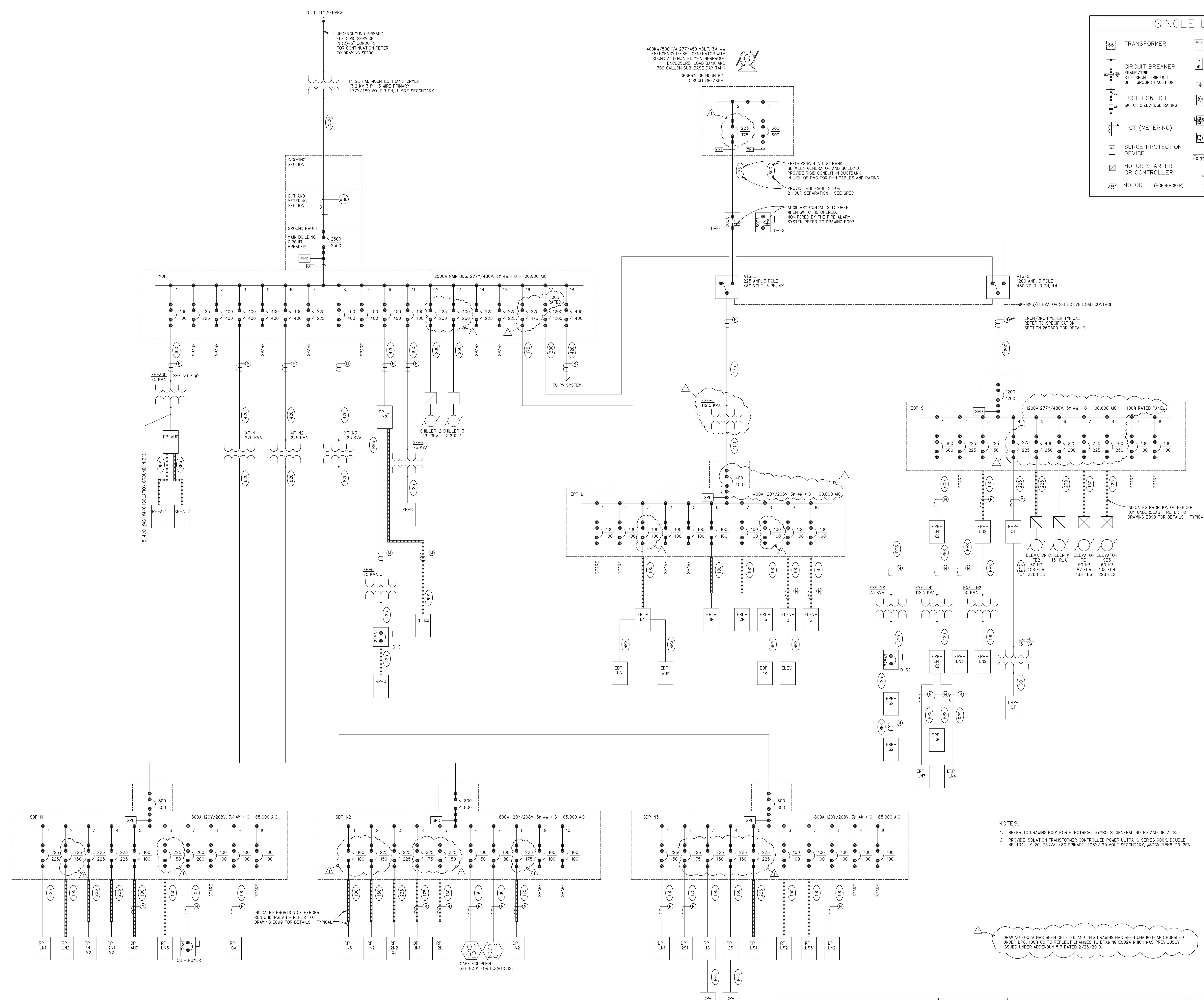
Appendix A

Riser Diagram of The Barnes Foundation



SINGLE LINE LEGEND

- TRANSFORMER
- CIRCUIT BREAKER — FRAME/TRIP; ST = SHUNT TRIP UNIT; GFI = GROUND FAULT UNIT
- FUSED SWITCH — SWITCH SIZE/FUSE RATING
- CT (METERING)
- SURGE PROTECTION DEVICE
- MOTOR STARTER OR CONTROLLER
- MOTOR (HORSEPOWER)
- LIGHTING/POWER PANEL
- LIGHTING PANEL WITH INTERNAL CONTACTOR
- GROUND PER NEC
- UTILITY COMPANY REVENUE METER PAN AND METER
- ENCLOSED FUSED SWITCH
- ENCLOSED CIRCUIT BREAKER
- NETWORKED CUSTOMER METERING EQUIPMENT SEE 16410
- BUS DUCT

CONDUCTOR & CONDUIT SCHEDULE

FEEDER SYMBOL	CONDUCTORS (3PH,4W) WITH GROUND	CONDUIT SIZE
20	4#12 + 1#12 G	(1) 3/4"
30	4#10 + 1#10 G	(1) 3/4"
40	4#8 + 1#10 G	(1) 3/4"
50	4#6 + 1#10 G	(1) 1"
60	4#6 + 1#10 G	(1) 1"
70	4#4 + 1#8 G	(1) 1 1/4"
80	4#4 + 1#8 G	(1) 1 1/4"
100	4#2 + 1#8 G	(1) 1 1/4"
125	4#1 + 1#6 G	(1) 1 1/2"
150	4#1/0 + 1#6 G	(1) 2"
175	4#2/0 + 1#6 G	(1) 2"
200	4#3/0 + 1#6 G	(1) 2"
225	4#4/0 + 1#4 G	(1) 2 1/2"
250	4#250KCM + 1#4 G	(1) 2 1/2"
300	4#350KCM + 1#4 G	(1) 3"
350	4#500KCM + 1#2 G	(1) 3 1/2"
400	4#500KCM + 1#2 G	(1) 3 1/2"
420	4#600KCM + 1#2 G	(1) 4"
450	8#4/0 + 2#2 G	(2) 2 1/2"
500	8#250KCM + 2#2 G	(2) 2 1/2"
600	8#350KCM + 2#1 G	(2) 3"
700	8#500KCM + 2#1/0 G	(2) 3 1/2"
800	8#500KCM + 2#1/0 G	(2) 3 1/2"
840	8#600KCM + 2#2/0 G	(2) 4"
900	12#350KCM + 3#2/0 G	(3) 3"
1000	12#500KCM + 3#2/0 G	(3) 3 1/2"
1200	12#600KCM + 3#3/0 G	(3) 4"
1600	16#600KCM + 4#4/0 G	(4) 4"
2000	20#600KCM + 5#250KCM G	(5) 4"
2500	24#600KCM + 6#350KCM G	(6) 4"
3000	32#600KCM + 8#400KCM G	(8) 4"
RPS	REFER TO PANEL SCHEDULE	-

NOTES:

1. PROVIDE 4-WIRE CIRCUIT, UNLESS DEVICE SERVED DOES NOT HAVE PROVISIONS FOR A NEUTRAL CONNECTION.
2. ALL CONDUCTOR SIZES ARE FOR COPPER CONDUCTORS, WITH 90 DEGREE INSULATION RATING.
3. FOR AN OVERCURRENT PROTECTION DEVICE OF INTERMEDIATE RATING OF THOSE LISTED, PROVIDE WIRING INDICATED FOR THE NEXT HIGHER RATED DEVICE.
4. VD=FEEDER UPSIZED DUE TO VOLTAGE DROP
   3W=3WIRE FEEDER (NO NEUTRAL) REQUIRED
   5W=5WIRE FEEDER (2X NEUTRAL) REQUIRED
5. FEEDERS ON TRANSFORMER SECONDARY SIDE SHALL CONTAIN SYSTEM BONDING JUMPER SIZED PER NEC 250-30(A)(1), & NEC TABLE 250-66.

NOTES:

1. REFER TO DRAWING E001 FOR ELECTRICAL SYMBOLS, GENERAL NOTES AND DETAILS.
2. PROVIDE ISOLATION TRANSFORMER CONTROLLED POWER ULTRA K, SERIES 600K, DOUBLE NEUTRAL, K-20, 75KVA, 480 PRIMARY, 208Y/120 VOLT SECONDARY, #8DGX-75K6-20-2FN.

1 DRAWING E002A HAS BEEN DELETED AND THIS DRAWING HAS BEEN CHANGED AND BUBBLED UNDER DP6: 100% CD TO REFLECT CHANGES TO DRAWING E002A WHICH WAS PREVIOUSLY ISSUED UNDER ADDENDUM 5.3 DATED 2/26/2010.

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KEY PLAN

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THE BARNES FOUNDATION
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PHILADELPHIA, PENNSYLVANIA

100% CONSTRUCTION DOCUMENTS FOR CONSTRUCTION

DRAWING ISSUE	
60% CD: FYI ONLY	12/04/2009
BUILDING PERMIT ONLY	02/08/2010
1 DP6: 100% CD	04/02/2010

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SCALE NONE

E002

SINGLE LINE DIAGRAM

0813EOP1

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FILE:E002DP1 REV: 04/01/10 15:29