Perot Museum of Nature and Science, Dallas, TX

Tech Report 2: Electrical System Existing Conditions

Oct 12, 2013

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Lighting/Electrical
AE Faculty Consultant: Dr. Shawn Good

Executive Summary

This report is a summary of my study about the existing electrical system of Perot Museum of Nature and Science. The report is divided into three major parts.

Part 1: This part of the report focused on calculates preliminary electrical load as well as identifying code requirements that applies to this project. The main target is to understand the ideal electrical system this project should have.

Part 2: This part of the report focused on understanding the current electrical system built into the project, including the building load, materials used and how is the system integrated.

Part 3: This part of the report compares the content of part 1 and part 2, thus discusses potential changes can be made to save operation cost and increase energy efficiency.

Overall, the existing building is carefully design that meets all the relevant electrical code. Change such as a secondary storm water tank and additional landscape vegetation are suggested to increase the energy efficiency.

Part 1

1. Preliminary Electrical Load Calculation

Building Area: 180,000 Square Foot
Estimated Lighting Unit Load: 4 Volt-Amperes / Square Foot
Estimated Receptacle Unit Load: 2.2 Volt-Amperes / Square Foot
Estimated Power Factor: 0.9
Estimated Mechanical Unit Load: 7 Volt-Amperes / Square Foot
Estimated Special Equipment Unit Load: 2 Volt-Amperes / Square Foot
Total Load = 180,000 * 15 = 2700KVA
I = 1000 * 2700/(3^0.5*277)=5525A

2. Power Company

'4 Charge Energy' is assumed to be the power company providing utility service

3. Rate Schedule

By balancing the consideration of cost control and operation flexibility, I recommend a 12-month rate with 277V service voltage.

Electricity Facts Label (EFL)
4CHANGE ENERGY Charitable Saver 12
Oncor Service Area
Issue Date: September 13, 2013

Electricity price

	Average price per kWh		
Average Monthly Use	500kWh	1,000kWh	2,000kWh
Oncor Electric Delivery	11.1¢	8.4¢	9.1¢

This price disclosure is an example based on average prices. The customer may elect to make this product 100% renewable for a charge of up to $4.95 a month. Your average price per kWh for electric service will depend on your usage and will include a credit of $20.00 if you use more than 999 kWh, an Energy Charge, and Transmission and Distribution Utility ("TDU") Pass-Through Charges noted below. This plan's features include Auto Pay and electronic document delivery.

TDU	Energy Charge	TDU per Month	TDU per kWh
Oncor Electric Delivery	6.5695¢	$6.48	3.2315¢

*These figures reflect TDU Delivery Charges as of the issue date of this EFL. TDU Delivery Charges will be passed through to you as billed from the TDU.

4. Utilization Voltage

Building: 277V, 3 phase
Lighting fixtures: single phase 120V & 277V
Receptacle: 120V, three phases.
Mechanical*:* single phase 120V & 277V, three phase 208V & 480V.
Special Equipment: 480V, 3 phase & 120V, single phase.

5. Emergency Power Requirement

Assume A-3 occupancy type, type 3 construction
IBC 2009 2702.1:
Emergency power is required where the loss of normal power would endanger occupants. Such systems are covered in Article 700 of NFPA 70 and one of their key features is the required response time of 10 seconds or less.
IBC 2009 2702.2 – 2702.20:
Emergency power is required at following locations:
2702.2.1 Group A occupancies (for egress)
2702.2.2 Smoke control systems
2702.2.3 Exit signs
2702.2.4 Means of egress illumination
2702.2.5 Accessible means of egress elevators
2702.2.6 Accessible means of egress platform lifts
2702.2.7 Horizontal sliding doors
2702.2.10 Hazardous materials
2702.2.15 High-rise buildings
2702.2.16 Underground buildings
2702.2.19 Elevators
2702.2.20 Smokeproof enclosures
NEC 700.4
(a) Capacity and Rating. An emergency system shall have adequate capacity and rating for all loads to be operated simultaneously. The emergency system equipment shall be suitable for the maximum available fault current at its terminals.
(b) Selective Load Pickup, Load Shedding, and Peak Load Shaving. The alternate power source shall be permitted to supply emergency, legally required standby, and optional standby system loads where automatic selective load pickup and load shedding is provided as needed to ensure adequate power to (I) the emergency circuits; (2) the legally required standby circuits; and (3) the optional standby circuits, in that order of priority. The alternate power source shall be permitted to be used for peak load shaving, provided the above conditions are met.
Peak load shaving operation shall be permitted for satisfying the test requirement of Section 700-4(b), provided all other conditions of Sec tion 700-4 are met. A portable or temporary

alternate source shall be available whenever the emergency generator is out of service for major maintenance or repair.

6. Special Occupancy Space

NEC 530: Motion Picture Projection Room

7. Potential Special Equipment

NEC 620: Elevator, Escalator
NEC 640: Audio Signal Processing, Amplification, and Reproduction Equipment

8. Priority Assessment

Flexibility will be the major concern since scene change often occurs for different exhibition, which accompanies equipment change that require different load.
Redundancy will be considered for similar reason above. A straight forward electrical system can speed up installation of new equipment.
Long Term Ownership Cost should be considered to increase the profit of the museum.
Reliability and **Power Quality** are secondary factors that will help to maintain operation.
Initial Cost is less of concern knowing that long term operation is planned.

9. Optional Back-up Power

Equipment in the bio lab might need back-up power to keep potential samples alive. Therefore an extra ATS is suggested as well.

10. Special/Communication System

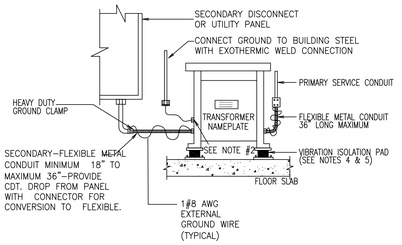
Fire Alarm
Security

11. Building Service Requirement

Telephone

12. Major Equipment

Equipment Schedule attach on next page

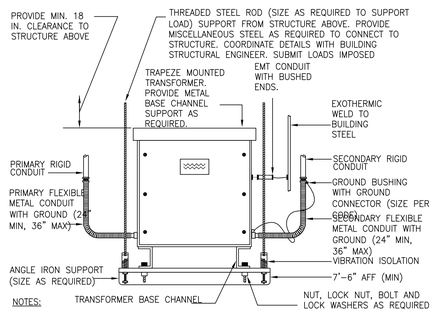


NOTES:

1. PROVIDE A MINIMUM OF 8" TO ALL WALLS AND EQUIPMENT FOR VENTILATION. (12" FOR 75KVA AND GREATER.) PROVIDE MIN. 24" CLEARANCE TO STRUCTURE, ABOVE TRANSFORMER.
2. INSULATED EQUIPMENT GROUND WIRE IN CONDUIT TO BUILDING STEEL. GROUND TO TRANSFORMER X/O EQUIPMENT GROUND STUD. CONNECT WITH SINGLE BOLT COMPRESSION GROUNDING LUG.
3. CONTRACTOR SHALL ENSURE ADEQUATE CLEARANCE FOR MAINTENANCE/INSPECTION.
4. THERE SHALL BE NO SOLID METALLIC CONTACT BETWEEN TRANSFORMER AND SUPPORTING STRUCTURE.
5. EXACT MOUNTING LOCATION OF TRANSFORMER SHALL BE APPROVED BY OWNER IN FIELD PRIOR TO INSTALLATION. ELECTRICAL CONTRACTOR SHALL VERIFY IN FIELD THAT INSTALLATION DOES NOT INFRINGE ON ANY EXISTING EQUIPMENT/PANEL(S) CLEARANCE AREAS.

E01 TRANSFORMER FLOOR MOUNTED

NOT TO SCALE

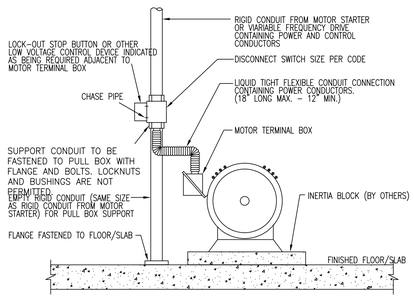


NOTES:

1. MAXIMUM SIZE TRANSFORMER FOR CEILING MOUNTING SHALL BE 75KVA, K13 RATED V.O.N.
2. PROVIDE A MINIMUM OF 8" TO ALL WALLS AND EQUIPMENT FOR VENTILATION. (12" FOR 75KVA AND GREATER.) PROVIDE MIN. 18" CLEARANCE TO STRUCTURE, ABOVE TRANSFORMER.
3. INSULATED EQUIPMENT GROUND WIRE IN CONDUIT TO BUILDING STEEL. GROUND TO TRANSFORMER X/O EQUIPMENT GROUND STUD. CONNECT WITH SINGLE BOLT COMPRESSION GROUNDING LUG.
4. CONTRACTOR SHALL ENSURE ADEQUATE CLEARANCE FOR MAINTENANCE/INSPECTION.
5. THERE SHALL BE NO SOLID METALLIC CONTACT BETWEEN TRANSFORMER AND SUPPORTING STRUCTURE.
6. EXACT MOUNTING LOCATION OF TRANSFORMER SHALL BE APPROVED BY OWNER IN FIELD PRIOR TO INSTALLATION. ELECTRICAL CONTRACTOR SHALL VERIFY IN FIELD THAT INSTALLATION DOES NOT INFRINGE ON ANY EXISTING EQUIPMENT/PANEL(S) CLEARANCE AREAS.

E01 TRANSFORMER WALL MOUNTED

NOT TO SCALE

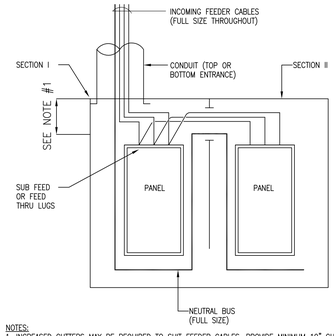


NOTE:

1. MOTOR SHALL BE FURNISHED AND INSTALLED BY OTHERS AND WIRED BY ELECTRICAL CONTRACTOR.

E01 FLOOR MOUNTED MOTOR CONNECTION

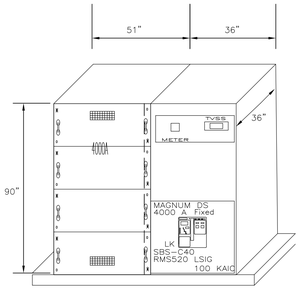
NOT TO SCALE



NOTES:
1. INCREASED GUTTERS MAY BE REQUIRED TO SUIT FEEDER CABLES. PROVIDE MINIMUM 10" GUTTER.
2. NEUTRAL SHALL PASS THROUGH SAME HOLE IN BARRIER AS PHASE CONDUCTORS.
3. PROVIDE GROUND BUS IN BOTH SECTIONS.
4. TYPICAL FOR 3 SECTION PANELS.

04 TYPICAL SUB–FEED METHOD MULTI–SECTION PANEL BOARD DETAIL

NOT TO SCALE



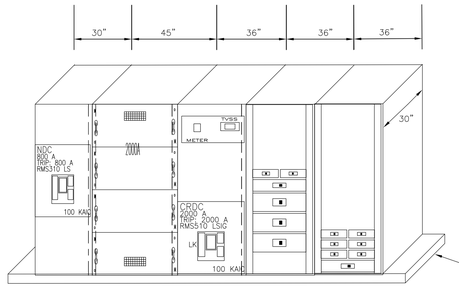
General Information

Pow–R–Line C, Front Access/ Front and Rear Align
System Voltage: 480Y/277V 3–Phase 4–Wire
Short Circuit Interrupter Rating: 100KA
Main Bus: 4000A, Neutral Bus: 4000A
Copper Bus
Copper Ground Bus
Bottom Incoming Lug Drilling(s): (10) EUSERC Press Bolts (1) #6–350 kcmil Ground Lug Supplied As Standard
Bus Bracing: 100kA

Service Entrance: Suitable Only For Use As Service Equipment
Switchboard Construction Meets UL–891
Enclosure: Type 1
Finish: ANSI–61
Estimated Weight: 2000 Lbs Per Section

E01 MAIN SWITCHBOARD "MS.01" ELEVATION

NOT TO SCALE



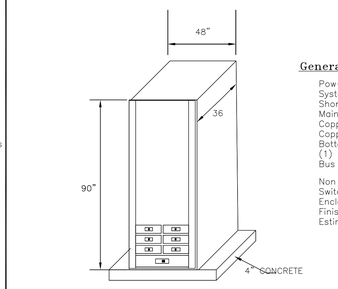
General Information

Pow–R–Line C, Front Access/ Front and Rear Align
System Voltage: 480Y/277V 3–Phase 4–Wire
Short Circuit Interrupter Rating: 100KA
Main Bus: 2000A, Neutral Bus: 2000A
Copper Bus
Copper Ground Bus
Bottom Incoming Lug Drilling(s): (7) EUSERC Press Bolts (1) #6–350 kcmil Ground Lug Supplied As Standard
Bus Bracing: 100kA

Service Entrance: Suitable Only For Use As Service Equipment
Switchboard Construction Meets UL–891
Enclosure: Type 1
Finish: ANSI–61
Estimated Weight: 1600 Lbs Per Section

E01 MAIN SWITCHBOARD "MS.02" ELEVATION

NOT TO SCALE



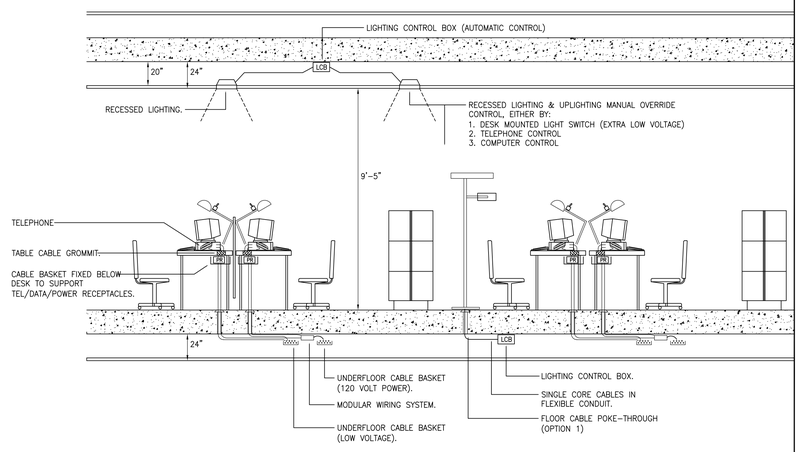
General Information

Pow–R–Line C, Front Access/ Front and Rear Align
System Voltage: 480Y/277V 3–Phase 4–Wire
Short Circuit Interrupter Rating: 65KA
Main Bus: 600A, Neutral Bus: 600A
Copper Bus
Copper Ground Bus
Bottom Incoming Main Lugs: (2) #2–500 kcmil (1) #6–350 kcmil Ground Lug Supplied As Standard
Bus Bracing: 65kA

Non Service Entrance
Switchboard Construction Meets UL–891
Enclosure: Type 1
Finish: ANSI–61
Estimated Weight: 1600 Lbs Per Section

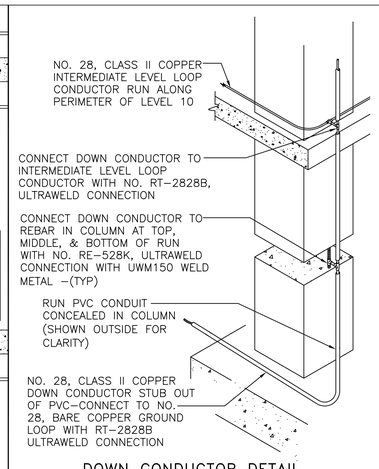
E01 EMERGENCY SWITCHBOARD "STSB.01" ELEVATION

NOT TO SCALE

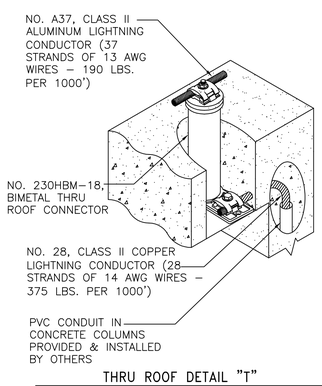


E01 TYPICAL OPEN PLAN OFFICE

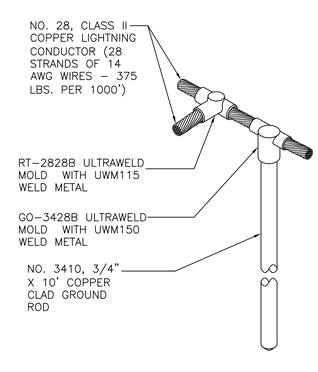
NOT TO SCALE



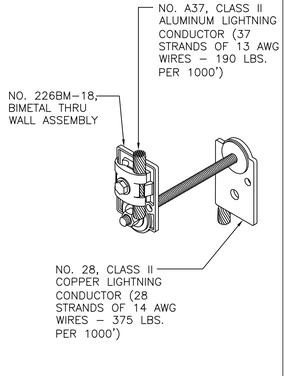
DOWN CONDUCTOR DETAIL



THRU ROOF DETAIL "T"



GROUND ROD DETAIL "G"



THRU WALL DETAIL "TW"

E01 TYPICAL LIGHTING PROTECTION DETAILS

NOT TO SCALE

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DALLAS, TEXAS

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fax: 424 - 258 - 6299
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Dallas, TX 75201
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fax: 214 - 303 - 1512
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02-10-2010		100% DD GMP
05-10-2010		50% CD/REF ONLY
07-19-2010		80% CD/REF ONLY
09-10-2010		100% CD

KEY PLAN:

100% CONSTRUCTION DOCUMENTS

PROJECT NUMBER: 28350.00
PHASE: CONSTRUCTION DOCUMENTS
DATE: 09-10-2010
SCALE: N/A

ELECTRICAL DETAILS -POWER 4

E-806.0

PATH

Part 2

1. Actual Connected Building Load

	Lighting	Largest Motor	Other Motor	Receptacle	Continuous	Heating	Noncontinuous	Kitchen	Diverse
Main Board MSB1	14.2	17.5	130	94.3	4.7	282	504	95.6	2100
Main Board MSB2	180	0.1	0.2	119	3	56	113	0	1270
Emergency Board	0	0	0	0	0	0	0	0	1610

Total building load is 4990KVA, total balanced three phase amps is 4880A.

2. Actual Power Company Rate

The Actual Power Company Rate is assumed to be a 24 month plan with '4 Charge Energy'

Electricity Facts Label (EFL)
4CHANGE ENERGY Charitable Saver 24
Oncor Service Area
Issue Date: September 13, 2013

Electricity price

	Average price per kWh		
Average Monthly Use	500kWh	1,000kWh	2,000kWh
Oncor Electric Delivery	12.1¢	9.4¢	10.1¢

This price disclosure is an example based on average prices. The customer may elect to make this product 100% renewable for a charge of up to $4.95 a month. Your average price per kWh for electric service will depend on your usage and will include a credit of $20.00 if you use more than 999 kWh, an Energy Charge, and Transmission and Distribution Utility ("TDU") Pass-Through Charges noted below. This plan's features include Auto Pay and electronic document delivery.

TDU	Energy Charge	TDU per Month	TDU per kWh
Oncor Electric Delivery	7.5695¢	$6.48	3.2315¢

*These figures reflect TDU Delivery Charges as of the issue date of this EFL. TDU Delivery Charges will be passed through to you as billed from the TDU.

3. Building Utilization Voltage

Building: 480Y/277V will be the utilization voltage provided to the building.

Lighting fixtures: Among 57 luminaires used in this project, 54 of them operate under 277V single phase power and 3 of them operate under 120V single phase power due to the characteristic of halogen luminaire.

Receptacle: Receptacles in the museum provide power in 120V, three phases.

Mechanical*:* HVAC equipment operates under 120V, 277V single phase as well as 208V and 480V three phases.

Plumbing equipment operates under 120V single phase and 480V three phases.

VAV equipment operates under 277V single phase and 480V three phases.

Special Equipment: Elevator and Escalator in the building operate under 480V 3 phase power. Biolab equipment in the museum consumes 120V single phase power. Pump for fire protection operates under 480V three phase power.

4. Emergency Load

Total Connection Load: 1610 KVA
Balanced Three Phase Amps: 812 Amp
Voltage: 480Y/277V 3 phase
Power Source: 750KVA Generator
Fuel: Assume to be Natural Gas for environment concern
Size: L = 150 in, W = 58 in, H = 85 in, referencing FG Wilson generator of same output
http://www.fgwilson.com/cda/files/3208301/7/P750-1(4PP)GB(0213).pdf
Distribution: Emergency power is delivered from the generator to the emergency board, then transferred into four automatic transfer switch as well as one manual transfer switch, from where the power will be supplied to specific fire pumps and lighting boards.

5. Special Occupancy Requirement

NEC 530: Motion Picture Projection Room
The room can be found on level 1 floor plan

6. Special Equipment

NEC 620: Elevator, Escalator
Located on floor plan level 1 to level 5

NEC 640: Audio Signal Processing, Amplification, and Reproduction Equipment
Located on level 1 floor plan

7. *Equipment Documentation*

Switch Board: 277V, 3 phase
Panel Board: 277V, 3 phase & 120V, single phase
Transformer: Interior floor mounted, 1500KVA, 13.2 KV primary/277V, 3 phase secondary
Step Down Transformer: Interior wall mounted, 145KVA, 120V, 3 phase
Feeders: Minimum size used is 1”C, Maximum size used is 4”C
Conductor: Cooper
Conduit: 3#2, 3#4, 3#6 3#600kcmil, etc. Assume PVC Conduit is used
Receptacle: 20A, Assume Commercial Grade
Receptacle Face Plate: Stainless Steel
Motor Starter: Fused, toggle switch or VFD with integral fuse

UPS: There is no dedicated equipment room found with UPS system applied

8. *Optional Back-Up Load*

Currently no equipment requires optional back-up load other than systems required by code. Recommendations are made in the next section to provide optional back-up power to certain equipment.

9. *Special Communication System*

Fire Alarm
Security

10. Building Service Equipment

Telephone

11. Electrical Space

Electrical Vault: 576SF
Basement Main Electrical Room: 216 SF
Basement Electrical Room: 258.5 SF
Basement Telecom: 144 SF
Level 1 Electrical Room: 143.5 SF
Level 1 Telecom: 132 SF
Level 5 Telecom: 217 SF

Total: 1687 SF
0.9% of the building area

12. *Energy Saving Equipment*

'Viessmann' vacuum tube solar collectors

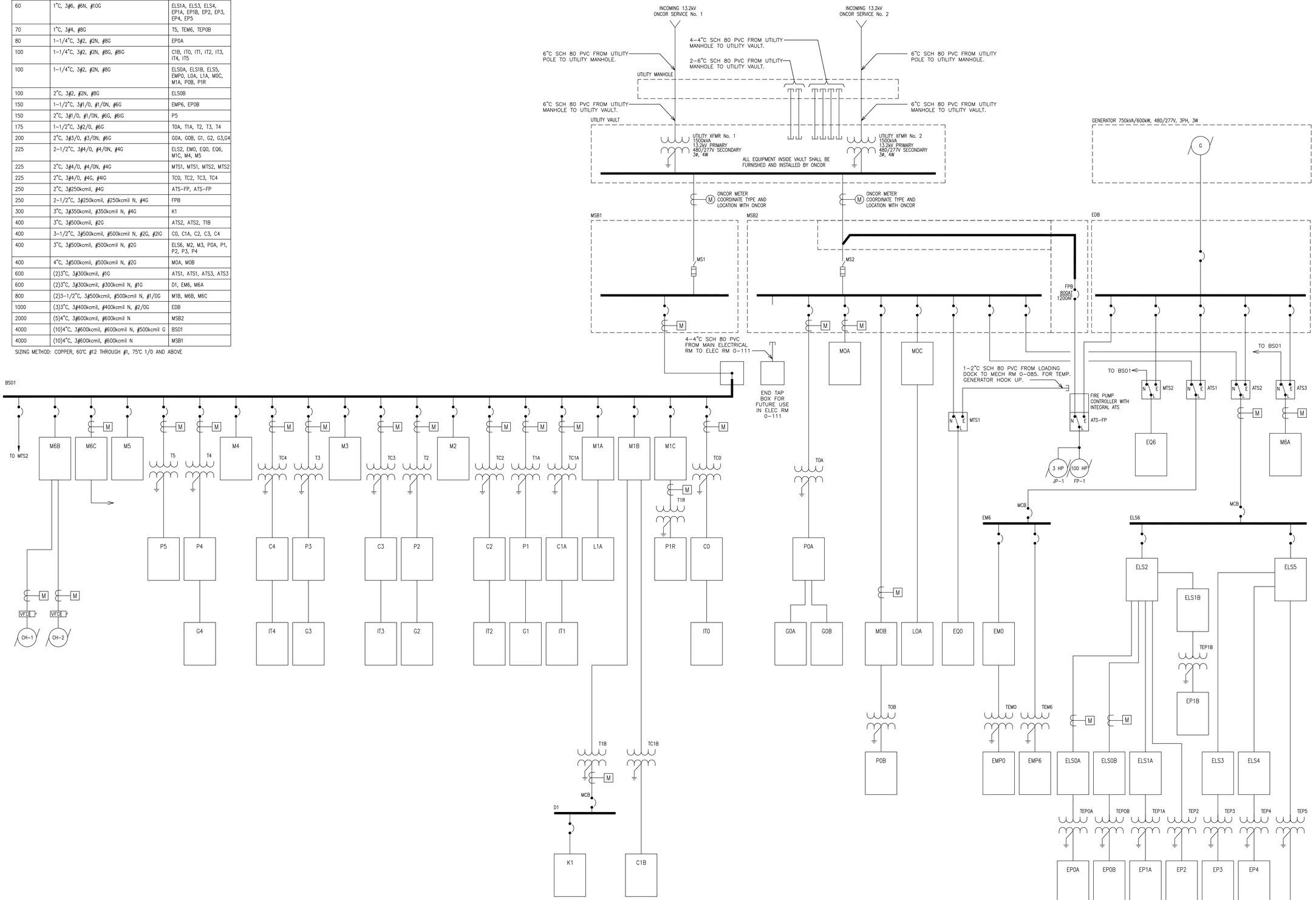
13. *Single Line Diagram*

Attached on next Page

FEEDER SCHEDULE

FEEDER AMPS	CONDUIT AND FEEDER	FEEDING THESE DEVICES
30	3/4"C, 3#10, #10G	TEP1A, TEP1B, TEP2, TEP3, TEP4
50	3/4"C, 3#6, #10G	T0B, T1R, TEM0, TEP0A, TEP5
60	1"C, 3#6, #6N, #10G	ELS1A, ELS3, ELS4, EP1A, EP1B, EP2, EP3, EP4, EP5
70	1"C, 3#4, #8G	T5, TEM6, TEP0B
80	1-1/4"C, 3#2, #2N, #8G	EP0A
100	1-1/4"C, 3#2, #2N, #8G, #8IG	C1B, IT0, IT1, IT2, IT3, IT4, IT5
100	1-1/4"C, 3#2, #2N, #8G	ELS0A, ELS1B, ELS5, EMP0, L0A, L1A, M0C, M1A, P0B, P1R
100	2"C, 3#2, #2N, #8G	ELS0B
150	1-1/2"C, 3#1/0, #1/0N, #6G	EMP6, EP0B
150	2"C, 3#1/0, #1/0N, #6G, #6IG	P5
175	1-1/2"C, 3#2/0, #6G	T0A, T1A, T2, T3, T4
200	2"C, 3#3/0, #3/0N, #6G	G0A, G0B, G1, G2, G3,G4
225	2-1/2"C, 3#4/0, #4/0N, #4G	ELS2, EM0, EQ0, EQ6, M1C, M4, M5
225	2"C, 3#4/0, #4/0N, #4G	MTS1, MTS1, MTS2, MTS2
225	2"C, 3#4/0, #4G, #4IG	TC0, TC2, TC3, TC4
250	2"C, 3#250kcmil, #4G	ATS-FP, ATS-FP
250	2-1/2"C, 3#250kcmil, #250kcmil N, #4G	FPB
300	3"C, 3#350kcmil, #350kcmil N, #4G	K1
400	3"C, 3#500kcmil, #2G	ATS2, ATS2, T1B
400	3-1/2"C, 3#500kcmil, #500kcmil N, #2G, #2IG	C0, C1A, C2, C3, C4
400	3"C, 3#500kcmil, #500kcmil N, #2G	ELS6, M2, M3, P0A, P1, P2, P3, P4
400	4"C, 3#500kcmil, #500kcmil N, #2G	M0A, M0B
600	(2)3"C, 3#300kcmil, #300kcmil N, #1G	ATS1, ATS1, ATS3, ATS3
600	(2)3"C, 3#300kcmil, #300kcmil N, #1G	D1, EM6, M6A
800	(2)3-1/2"C, 3#500kcmil, #500kcmil N, #1/0G	M1B, M6B, M6C
1000	(3)3"C, 3#400kcmil, #400kcmil N, #2/0G	EDB
2000	(5)4"C, 3#600kcmil, #600kcmil N	MSB2
4000	(10)4"C, 3#600kcmil, #600kcmil N, #500kcmil G	BS01
4000	(10)4"C, 3#600kcmil, #600kcmil N	MSB1

SIZING METHOD: COPPER, 60°C #12 THROUGH #1, 75°C 1/0 AND ABOVE



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02-10-2010		100% DD GMP
05-10-2010		50% CD/REF ONLY
07-19-2010		80% CD/REF ONLY
09-10-2010		100% CD

KEY PLAN:

100% CONSTRUCTION DOCUMENTS

PROJECT NUMBER: 28350.00
PHASE: CONSTRUCTION DOCUMENTS
DATE: 09-10-2010
SCALE: NTS

ONE LINE DIAGRAM

E-700.0

Part 3

1. Load Comparison

The estimated load is 5225A, larger than the actual 4990A load.

2. Power Company Comparison

Bounce Energy offer a better rate at 6.8 cent / KWH

3. Building Utilization Voltage

Building: 277V ensures an efficient power transfer with limited current loss. Therefore, no change is suggested

Lighting fixtures: Lighting voltage is specified per product, voltage should not be changed

Receptacle: Receptacle voltage must be kept the same to match operation load of typical electronic devices

Mechanical*:* Mechanical voltage is specified per product, voltage should not be changed

Special Equipment: Special equipment voltage is specified per product, voltage should not be changed

4. Emergency Power System

Current emergency power system meets code standard, no change is required

5. Equipment Comparison

Current equipment meets code standard, no change is required

6. *Optional Back-up Power*

Bio lab equipment consumes 17 KVA, which could be moved from regular board to ATS board for backup power supply. This change adds 1% additional emergency load that will not require resize of generator. An additional ATS will be added into the system for emergency power distribution.

7. Cost Reduction

Some luminaires can be replaced to higher efficacy luminaries to increase energy efficiency. For example, if we replace AL-13, a 70W halogen luminaire, with a 9W LED lamp while having the same output, we can save 80W*2000Hr (rough operation hour per year)*10c=$16 saving per year.

8. *System Integration*

Current mechanical system collects all the storm water and stores them on the landscape level. When needed, storm water will be pumped to higher level. I believe if we set up a secondary tank on the roof that serves upper floor, we can reduce the energy used to pump water all the way up.

9. *Cost Saving Strategy*

The theater of the museum on level 1 is partially embedded into the landscape plinth. The soil on the landscape become a natural heat barrier that suppresses the heat loss in the winter as well as heat gain in the summer. This design can be enhanced by plant shrubs on the landscape. The root of plant helps to increase the soil density, make it a more efficient heat barrier. Leaves of the plant also help to block sunlight from striking directly on the landscape.