Technical Report II

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Executive Summary:

This report details design criteria, as built conditions, and a comparison of the criteria and existing electrical systems for The Nerman Museum of Contemporary Art at the Johnson County Community College in Overland Park, Kansas.

In this report, the electrical systems are defined in scope and in characteristic for the building's occupancy as a museum. Electrical loads are summarized in preliminary and actual load calculations to assess electrical design. The electrical system as a whole is quantified and qualified giving specifications and identification to each piece of equipment and how they are linked together as a whole. Communication systems are also considered in the scope of this report.

The current electrical design of the Nerman Museum is very simple and straightforward which is very suitable for a building so small in size. A UPS system could be integrated into the distribution to provide the security system uninterrupted power during a blackout. There is also considerable opportunity to enhance the energy efficiency of the lighting and HVAC control systems such as VSD's and other communication systems. Finally, a PV array could be used to generate electricity to cut energy use and cost savings. A PV system makes sense since the Nerman Museum is located in a high area of solar radiation.

Table of Contents:

Building Overview:

Location Building name

The Nerman Museum of Contemporary Art

Location and site

Johnson County Community College

Overland Park, KS

Building Occupant Name

The Nerman Museum

Occupancy or function types

Education | Art Gallery | Café

Size

38,190 SF

Number of stories above grade / total levels

2 stories above grade | 2 total

Dates of construction

Start: April 2005

Completion: August 2007

Actual cost information

Approx. $15 million

Details not released

Project delivery method

Design Bid Build

Part I: Electrical Criteria & Scope of Work:

In this section, the criteria for an electrical system is researched and reported for a museum of the building of study's size. Using NEC (2011), IBC, and general guidelines, this part of the report attempts to qualify electrical equipment, electrical priorities and organization, and provide a preliminary load calculation based on NEC and square foot methods.

Criteria Identification

power company

Since the Nerman Museum is part of the Johnson County Community College, it is directly connected to the campus electrical system. The utility company supplies electricity to the college at a centralized location, and then each campus building is fed through their own distribution system. The museum's power usage is monitored by the college by a meter located on the man bus of the switchboard located inside the building.

preliminary rate schedule / service voltage

The building does not have a rate schedule due to the fact that JCCC owns the power.

preliminary building utilization voltage

Since the power provided to the museum is tied into the community college, the service entrance voltage is distributed at a higher voltage. It makes sense to bring the power down to the higher voltage -480/277V- where applicable. Obviously plug load will have to be the standard 120V for compatibility reasons.

Lighting: 277V will be strived for unless unavailable for redesign.

Receptacle: 120V.

Mechanical: 480V will be strived for unless unavailable for redesign.

Special Equipment:

emergency power requirements

Emergency lighting and illumination of exit signs need to be supplied with power at all times according to the IBC 2006. Elevators considered part of egress should also be on emergency operation power. Elevators not part of egress should be on standby power and should be operational after sixty seconds of power loss. These loads are only a fraction of the overall power use and should be supplied by a generator. Since the museum is on campus and in the electrical system of the college, it makes sense that there would be a centralized generator for multiple buildings to run on during a power failure.

special occupancy requirements

The Nerman Museum needs to comply with article 518 "Assembly Occupancies" of the NEC 2011 Chapter 5.

special equipment

Based on NEC 2011 Chapter 6 "Special Equipment":

Article 620: Elevators

priority assessment

The priority list below is based on acceptable failure rate importance to the building occupancy of the museum.

Priority: Low | Medium | High

Reliability: Medium

The reliability of the power coming into the museum is fairly crucial because the building is used as a school building as well as a museum. Having learning interrupted costs the college money and time.

Power Quality: Medium

The power quality of the electrical system is also fairly important. It allows the college to use computer equipment without strain on the system. The museum uses a lot of computer equipment and electronic ballasts so cleaning up the power is seen as important.

Redundancy: Low

The redundancy of the electrical system does not need to be too robust since nothing in the building is extremely critical to supply power to. A moderate attempt to back up high priority systems seems to be sufficient for this type of building.

Low Initial Cost: Low

The college is typically looking for a building of quality because they will be the ones who upkeep the system once it is turned over to them. A quality electrical scheme typically cost more money, but the investment in higher cost and quality equipment will most likely provide further cost savings down the road.

Long Term Ownership Cost: High

As stated above, the long term ownership cost wants to be low compared to a cheap system with little cost upfront.

Flexibility: Low

With this building being a museum and having a set program to which the building belongs, the flexibility of the power system is not as crucial because the building type doesn't need to be flexible.

optional back-up power loads

Other than emergency power loads, the only other back-up power loads that need to stay online would be the security system. This will probably need a UPS system to keep it online with the generator supplying once operational.

special / communications systems

Telephone/data: Needed for classroom support for communication with other college buildings.

Fire Alarm: Section 907 of IBC 2006.

Access Control: Card readers for door access should be required for museum security.

Security: Intrusion detection and video surveillance should both be required for security in a museum.

major equipment

The other major equipment needed for this building type would be loading dock lifts for large art installations needed to be hoisted into position throughout the gallery areas. Hoist and cranes may also be needed to move and assemble art pieces as necessary.

Preliminary Load Calculation

The below tables lay out two different preliminary load calculation methods. The first table, the square foot method, is used during schematic design phase to get a reasonable estimate based on the building type and its area. The NEC loading method (second table) is used during the design development phase to narrow down what type of electrical loading might be used in the building. It uses the building area or area specific to the load type, which is multiplied by a multiplier of VA/ft^2. This method is more accurate to actual sizing.

Tables on next page.

Preliminary Electrical Load Calculation: Square Foot Method

Building Type	Area (ft^2)	VA/ ft^2	VA
college buildings: museum	38,000	6.5	247,000
		total kVA	247
		total current at 480V (amps)	297
		recommended switchboard size (amps)	300

Preliminary Electrical Load Calculation: NEC Loading

Load Type	Area (ft^2)	VA/ ft^2	VA
lighting (DF=1)	38,000	3	133,000
receptacles	38,000	1	38,000
HVAC	38,000	7	266,000
elevators (Qty=2)	-	50000 per unit	100,000
		total kVA	537
		total current at 480V (amps)	646
		recommended switchboard size (amps)	800

Part II: Electrical Systems as Designed:

This section will deal with the 'as built' electrical system. Using the final documentation –MEP building sheets- this part of the report will identify electrical systems, provide specifications on actual electrical equipment, and deliver an actual load calculation based on panelboard schedules as drawn.

Electrical Systems Identification

actual power company rate schedule

The building does not have a rate schedule due to the fact that JCCC owns the power.

building utilization voltage

The voltage to the building is provided at a medium voltage and then is stepped down to 480/277V to the main switchboard. Here it is distributed where necessary to all electrical equipment. There are some local transformers that step the power down to 240/120V that are then used on some equipment and lighting loads, as well as the receptacles.

Lighting: 277V and 120V where necessary.

Receptacle: 120V.

Mechanical: 480V and 240V where necessary.

Special Equipment: 480V and 240V where necessary.

emergency power systems

Life safety systems, during a power outage, need to be able to receive power continuously. Emergency and standby power feeds into emergency panel at 480/277V, 3P, 4W feeder from a existing generator from another campus building (Regnier Center).

The emergency panel then feeds one ATS to the main switchboard. The ATS serves emergency power for exit lighting, elevators, fire alarm systems, security, necessary pumps, and receptacles for mechanical and electrical equipment. When the main service power is interrupted, a signal is sent to the off-site generator to startup and to activate the ATS. The emergency panel board is then activated at that time.

special occupancy requirements

The Nerman Museum needs to comply with article 518 "Assembly Occupancies" of the NEC 2011 Chapter 5.

special equipment

There are two special pieces of equipment located in the building that service the kitchen. One is located at the kitchen dock which is the kitchen dock lift. It is located electrically on the 1HD1 panelboard and is supplied with 3P-F20A power and has a 30A breaker downstream. The other special piece of equipment is located next to the utility transformer which is the trash compacter. It is also supplied with 3P-F20A and has a breaker of 30A.

optional back-up power

There does not seem to be a UPS system to keep the security system online in the event of a power failure.

special / communications systems

Telephone/data: Electrical drawings on the first and second floor show data and tele. lines. The telephone and data account for about 10% of the total square footage.

Fire Alarm: Section 907 of IBC 2006. MEP drawings show a fire alarm system in place.

Access Control: There does not seem to be access control on any security doors on the drawings provided.

Security: There does not seem to be security on any drawings provided. Could be included on outside security consultant drawings.

electrical and communications systems spaces

The electrical room shares a space with the mechanical room and is located on the first floor, in the middle of the building just off the main staircase. This serves as a nice central located for easy distribution to the electoral loads throughout the building. The room number is M114.

energy cost savings | energy reduction techniques

There doesn't seem to be any real energy cost savings other than the college buys their own power at a higher voltage which is cheaper than supplying each and every building. The building's own electrical equipment is not seen to be any specialized equipment to save money or energy.

Some day-lighting techniques are used to supplement lighting during usable daylight hours which saves on lighting energy use.

Specifications

main service & distribution equipment

Coming off the primary JCCC loop, the power comes to the building on the north side where the utility transformer is located. It is then transferred down to 480/277V that then feeds into the switchboard. A TVSS is located here to clean up the power that results from harmonic loading downstream.

main service equipment

The main switchboard (MS-E1) is located in the mechanical / electrical room 'M114' on the first floor which has access to the loading dock in the backside of the building. Five sets of 4-#400MCM, 3"Conduit comes into the switchboard from the transformer. This room is also where most of the secondary panelboards are located that distribute to the kitchen and various lighting loads on the first floor.

Metering is used at the service entrance before the main 1600A breaker on the switchboard but after the transformer. Grounding is also utilized through a concrete encased electrode as well as the water pipe and building steel to ground the switchboard and electrical system.

main service transformer

The main transformer is located in a space on the north side of the building, away from the more public areas. The transformer shares the space with the trash compactor and dumpster.

distribution step down transformers

The distribution step down transformers are located with their respectable panelboards when there needs to be 120V to service equipment such as lighting and receptacle loads.

panelboards

The panelboards servicing the first floor for lighting, receptacles, kitchen equipment, and special equipment are located in the mech/elec room, M114. The emergency panelboards are also located there.

main risers and feeders

The main risers and feeders that service the building are of copper material as it is the most efficient and cost effective source to use.

conductors

Coming off of the switchboard, the lighting and receptacle loads are carried with 4-#250MCM, #4G. The mechanical and kitchen equipment panelboards need 2 sets of 4-#500MCM, #1/OG. The emergency panel is supplied with 4-#4/0, #4G conductors. These are all denoted by feeder numbers on the riser diagram that supply various types of amps. Conductors are all copper in material.

conduit

The conduit sizing for each conductor configurations are located on the riser diagram under 'schedule for conduit and conductors.' Here, the building uses anything from ½" C for small branch circuits to 3" C for large feeders.

receptacles

All receptacles are provided with 120V power. The receptacles are located throughout the museum and are commercial grade receptacles. There are a lot of receptacles that are located in the floor of the various rooms especially the gallery spaces. These require details of an adjustable floor box where it can be raised and lowered to meet the finished floors. These floor units are metal to match the high grade material of the floor while the wall units are plastic to blend with the white drywall.

motor starters

Not enough information on VSDs or any motor starters.

ups

There is not an in-house UPS system.

single line diagram

See Appendix A.

Actual Connected Load Calculation

The table below takes numbers from the actual panel schedules and applies a demand factor to get a realistic actual load calculation. A 20% spare capacity is also added to the total load volt-amps to act as protection for overdraw.

Actual Electrical Load Calculation

Load Type	Connected Load (VA)	Demand Factor	Demand Load (VA)
lighting			
receptacles			
fans			
cooling			
electric water heaters			
pumps			
elevators			
		total kVA	
		total kVA (add 20% for spare capacity)	
		total current at 480V (amps)	
		total current at 480V (amps) (add 20% for spare capacity)	
		recommended switchboard size (amps)	

Part III: Evaluation of Design vs Criteria:

In this part of the report, the designed system is compared to the criteria set in the first part of the report. This part will look at differences between the design and criteria and whether there are any possible upgrades or changes needed to bring the design to a higher level or bring it up to current code requirements.

Comparison of Electrical Systems

power company rate schedule alternatives

There don't seem to be any rate schedule alternatives since the power is supplied by the JCCC loop and owned by the college.

building utilization voltage & distribution alternatives

I think working at the higher voltage of 480/277V where you can is smart because you don't need as many secondary transformers and it saves on losses in the wire.

Overall, the electrical system for this building is simple and straightforward. I do not see how, at this time, there would be any desirable fundamental distribution concepts that I would change. Other than using different materials or equipment, the distribution seems to be very adequate. For a building that is small and tied into a larger gird, there aren't too many big distribution improvements that can be employed it seems.

Switching the lighting loads to all 277V seems to make sense since you would need a smaller size transformer and panelboard to handle the 120V receptacle loads.

emergency power system inconsistencies / changes

The emergency power coming from a generator that can supply multiple buildings seems to be an effective choice given the large number of buildings the college has to service. JCCC does have this system in place.

There does not however seem to be a UPS system and that seems to be flaw in the electrical system. The security system seems to be important enough for an uninterrupted power supply. Therefore it seems that a UPS system needs to be integrated to the electrical scheme.

Specifications Comparison

main service and distribution equipment

Having the main service transformer in a fenced off area on the outside of the building seems to be a logical choice. Having the switchboard in the joint mechanical and electrical also seems to make sense since it is located in a central location.

main service equipment

For the size of the museum, a switchboard seems to make sense.

main service transformer

Not enough is known about current transformer to see if it the most efficient or cost effective. Nor is it known if the transformer was in the scope of the Nerman Museum construction and therefore a lack of information on the specifications of the main transformer.

distribution step down transformers

The step down transformers seem to be adequate.

panelboards

Panelboards seem to fill design criteria in NEC for NEMA enclosures and usage. These are subject to change with redesign of electrical system.

main risers and feeders

Using copper feeders seems to be the best approach for an effective middle ground between cost savings, losses in the wire, and overall efficiency.

conductors

Conductor sizing are accurate with conductor criteria. Conductor sizing may change with electrical scheme changes on an individual basis.

conduit

Conduit sizing and usage are on par with criteria. As equipment and electrical schemes change, re-sizing may occur. A different conduit material may be looked at as well for greater cost savings or energy savings.

receptacles

The receptacles are commercial grade and this lines up with the design criteria so there doesn't seem to be any reason for change.

motor starters

Not enough information on VSDs or any motor starters.

ups

There doesn't seem to be a UPS system located in the building. It could be located off site that is tied into the ATS which has the generator or emergency power loop from the college on it.

Preliminary vs Actual Load Calculation

The first of the two tables below compare the three methods to calculate the total electrical load. Each result gave a different answer. The second table below describes the actual switchboard sizing and capacity as specified on the drawings.

Service Entrance Sizing: Comparison

Phase	Load (VA)	Voltage system	Load (Amps)
preliminary – square foot method	247	480/277V, 3P, 4W	297
preliminary – NEC method	537	480/277V, 3P, 4W	646
actual method		480/277V, 3P, 4W	

Service Entrance Sizing: Actual

Service Entrance	Capacity (kVA)	Voltage system	Size (Amps)
actual conditions – service entrance	1,330	480/277V, 3P, 4W	1600
		summary – VA/ft^2	34.8

In the table above, the switchboard size is taken from the single line diagram. I then calculated the kVA capacity using three phase amps to volt amps calculation formula. This is the as built actual loading from the documentation and is not calculated. There might be so much discrepancy because the owner wanted some future expansion later down the line.

The summary is an easy way to gauge the overall power used in the building. It is a lot higher than my initial square foot calculation method. There are some demanding lighting and electrical loads for this style building, but it does seem to be using a lot of energy. Another reason why this might be is due to the fact that this building was finished in design in 2004 which is almost a decade from the current standards.

Potential Electrical System Upgrades

back-up power and ups systems

There is an obvious need for back-up power for the security system secures the art pieces at night and during the day. These systems can never be allowed to go offline. A UPS system would allow this system to stay online and keep the art works safe.

transformers

More information is needed about the transformer.

vsd's

VSD's are a great way to save cost over the long term and that is a high priority for this type of building. This would be a great way to upgrade the equipment efficiency and save money and energy.

systems integration

The UPS could act as a TVSS to clean up the power and therefore the TVSS might not be needed saving in cost.

Using on-site energy generators to supply part of the buildings load, especially at peak hours would be a great way to integrate the electrical system and save money and energy.

Energy Cost Savings Evaluation

energy cost savings | energy reduction techniques

Using cogeneration or any on-site energy producers to supplement part of the electrical load would result in energy cost savings and energy reduction in the long run. PV arrays might prove useful because Overland Park, Kansas is located in the upper 2/3's of the solar radiation of the earth. PV generator might actually be a viable source of energy that would provide a reasonable payback period.

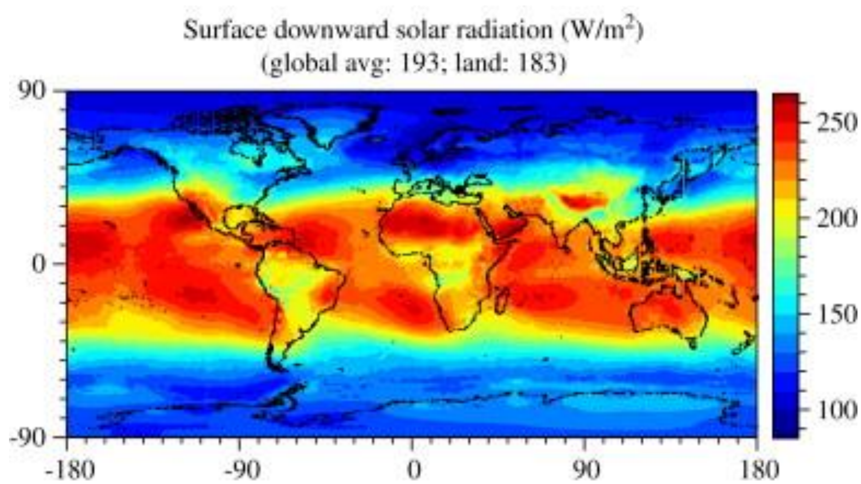


fig 1: solar radiation map

Appendix A:

Single Line Diagram

<See end of document>

Panel Schedules

Incomplete

Equipment Schedules

Air Cooled Chiller Schedule

Unit	Voltage/Phase	Wire/Conduit	Overcurrent Device	Disconnect
CH-1 Trane RTAC-200 STD	460/3	(3)#500MCM, #3G / 4" C.	350A-3P CB	400A-3P

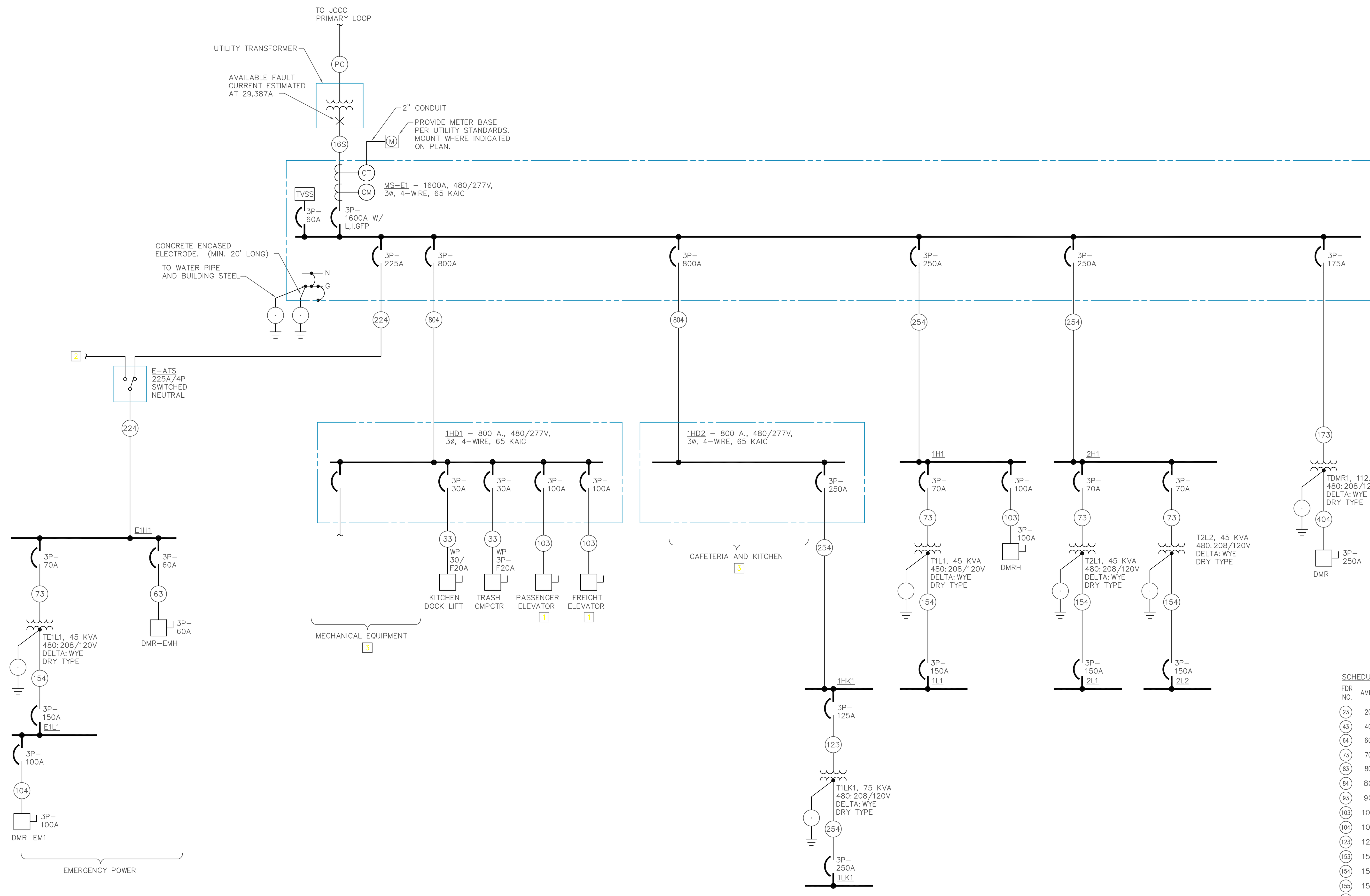
Citation:

Fig. 1: taken from “Brown carbon: A significant atmospheric absorber of solar radiation”

http://www.sciencedirect.com/science/article/pii/S0301421510008645

PLAN NOTES:

- PROVIDE BUSSMAN POWER MODULE DISCONNECT WITH SHUNT TRIP ACTUATION BY ELEVATOR SYSTEM HEAT DETECTORS.
- CONTINUED ON REGNIER CENTER ONE-LINE DIAGRAM.
- REFER TO MECH/ELEC SCHEDULES AND DETAILS FOR ADDITIONAL INFORMATION.



ONE-LINE DIAGRAM – ELECTRICAL

NO SCALE

SCHEDULE FOR CONDUIT AND CONDUCTORS

FDR NO.	AMPS	DESCRIPTION
23	20	3-#12, #12G, 1/2"C
43	40	3-#8, #10G, 3/4"C
64	60	4-#4, #10G, 1 1/4"C
73	70	3-#4, #8G, 1"C
83	80	3-#3, #8G, 1"C
84	80	4-#3, #8G, 1-1/4"C
93	90	3-#2, #8G, 1-1/4"C
103	100	3-#1, #8G, 1-1/4"C
104	100	4-#1, #8G, 1-1/2 "C
123	125	3-#1, #6G, 1-1/4 "C
153	150	3-#1/0, #6G, 1-1/2"C
154	150	4-#1/0, #6G, 1-1/2"C
155	150	3-#1/0, #250MCM N, #6G, 2"C
173	175	3-#2/0, #6G, 1-1/2"C
203	200	3-#3/0, #6G, 2"C
204	200	4-#3/0, #6G, 2"C
223	225	3-#4/0, #4G, 2"C
224	225	4-#4/0, #4G, 2-1/2"C
225	225	3-#4/0, #500MCM N, #4G, 2-1/2"C
254	250	4-#250MCM, #4G, 2-1/2"C
303	300	3-#350MCM, #4G, 2-1/2"C
304	300	4-#350MCM, #4G, 3"C
353	350	3-#500MCM, #3G, 3-1/2"C
403	400	3-#500MCM, #3G, 3"C
404	400	4-#500MCM, #3G, 3-1/2"C
503	500	2 SETS 3-#250MCM, #2G, 2-1/2"C
504	500	2 SETS 4-#250MCM, #2G, 2-1/2"C
604	600	2 SETS 4-#350MCM, #1G, 3"C
803	800	2 SETS 3-#500MCM, #1/0G, 3"C
804	800	2 SETS 4-#500MCM, #1/0G, 3-1/2"C
805	800	2 SETS 3-#500MCM, 2-#500MCM N, #1/0G, 4"C
904	900	3 SETS 4-#400MCM, #2/0G, 3"C
1203	1200	4 SETS 3-#350MCM, #3/0G, 3"C
1204	1200	4 SETS 4-#350MCM, #3/0G, 3"C
1205	1200	4 SETS 4-#400MCM, #3/0G, 3"C
1603	1600	5 SETS 3-#400MCM, #4/0G, 3"C
1604	1600	5 SETS 4-#400MCM, #4/0G, 3"C
2003	2000	6 SETS 3-#400MCM, #250MCM G, 3"C
16S	1600	5 SETS 4-#400MCM, 3"C

ONE-LINE DIAGRAM ELECTRICAL

E300

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