Woolly Mammoth Theatre
Washington DC

Kate Feato
Technical Report #2
Electrical Advisor: Professor Dannerth
Lighting Advisor: Dr. Mistrick
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Kate Feato
Lighting/Electrical Option
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Executive Summary

This report is an analysis of the existing electrical system in the Woolly Mammoth Theatre. The report will explain a general overview of the power distribution system and communication systems in the building. Included is a narrative that incorporates, but is not limited to descriptions of transformers, various voltage systems, emergency power systems, overcurrent protection devices, typical lighting systems and important design requirements.

In addition to the narrative described above, a summary of the total building electrical loads and a check of the size of the main distribution equipment are provided. This was found using the National Electric Code (2005); along with the panel boards, schedules and drawings for the theatre. The mechanical, lighting, receptacle and elevator loads were found and documented. Then the main distribution transformers, feeders and circuit breakers were sized to check the existing conditions.

Also included in this report is the existing utility rate structure and previous year electric load usage from the Potomac Electric Power Company, the current power supplier to the building. This rate structure is broken down into distribution services, generation services and transmission services. From that breakdown, it is further separated to on-peak energy, int-peak energy and off-peak energy. Other charges documented in the rate structure are maximum demand, customer charge, public space occupancy surcharge, reliability energy trust fund and procurement cost adjustment. The electric utility load data usage for the previous year was documented and compared to the service entrance load available.

Lastly, a general overview of the communication systems is included. The standard communication systems the theatre, as in most buildings, are the fire alarm system and telephone/data system. A specific communication system to the theatre is the audio visual system.

Feeder Sizes

FEEDER SCHEDULE					
FEEDER	**SERVING**	**SERVING FROM**	**WIRE**	**CONDUIT**	**GROUND**
1	L4	S1	4 #5000 KCMIL	3- 1/2 "	1 #3
2	M3, M2	S1	4 #5000 KCMIL	3- 1/2 "	1 #3
3	L5	S1	4 #4/0	2- 1/2"	1 #4
4	TP, 100 A AUDIO	S1	3 #250 KCMIL	2- 1/2"	1 #4
5	T1	S1	4 #1	1- 1/2"	1 #8
6	T	S1	4 #5000 KCMIL	3- 1/2 "	1 #3
7	DM1	S1	(2) 3 #400 KCMIL, 2 #400 KCMIL N	3- 1/2 "	1 #2
8	DM2	S1	(2) 3 #400 KCMIL, 2 #400 KCMIL N	3- 1/2 "	1 #2
9	M1	S2	4 #5000 KCMIL	3- 1/2 "	1 #3
10	CH-1	S2	(2) 3 #250 KCMIL	2- 1/2"	1 #1
11	ELEVATOR	S2	3 #1	1- 1/2"	1 #6
12	FREIGHT ELEVATOR	S2	3 #1/0	1- 1/2"	1 #6
13	WH	S2	3 #3/0	2"	1 #6
14	WH	S2	3 #3/0	2"	1 #6
15	PB	S2	4 #5000 KCMIL	3- 1/2 "	1 #3

System Type

The theatre has radial distribution system. The main electrical room is located in the back corner of the main part of the building (the 12 story mixed use facility/retail) that the theatre is a part of. An existing 4000 A utility c/t runs power to the theatre. Two 2000 A switchboards split from the existing 4000 A and are run to the theatre part of the building. These two main switchboards distribute power to the theatre. The loads are split up by running mechanical equipment from switchboard S2 and lighting/receptacles from switchboard S1.

Building Utilization Voltage

The Woolly Mammoth Theatre is a part of a large mixed use facility. Therefore there were constraints on the voltage systems that would be running in the theatre. The theatre utilizes only one voltages system throughout the space. It is a 208Y/120 system.

Emergency Power System

Emergency fixtures are circuited on separate relays throughout the theatre. These relays are located on panelboard E. This panelboard resides in the shop in the back of the building. This panelboard is a specific emergency panelboard. It is also tapped in to the existing building power system. Therefore when the normal power in the theatre is lost, the existing building emergency system will provide power for the emergency relays and lights. There is an emergency lighting transfer switch panel.

Overcurrent Protection Devices

In the main electrical room there is an existing 4000 A fused bolted pressure switch, along with (2) 2000 A fused bolted pressure switches. Protecting the panels running off of the two main distribution panels are circuit breakers ranging from 100 A to 600 A on panel S1 and circuit breakers ranging from 30 A to 400 A on panel S2. Also used are fused disconnects ranging from 600 A to 200 A. These fused disconnects are protecting the audio equipment and the two dimmer racks DM1 and DM2.

Location of Switchboard and Panelboards

The (2) 2000 A bolted pressure switches are located in the main building electrical room (the 12 story multi-use facility which the theatre is located in). Bus Duct (2000 A) is run from this electrical room to the Woolly Mammoth Theatre. The 2000 A switchboard (S2) for the mechanical equipment is located in the mechanical room on the 1st floor. The 2000 A switchboard for the

lighting/dimming/receptacles (S1) is located in the dimmer room on the 2nd level (street level). There are a few other panels located throughout the floors in smaller mechanical rooms, control rooms and equipment rooms.

Lighting Systems

Throughout the theatre there are incandescent, halogens, compact fluorescent and linear fluorescent lamps. In the lobby there are surface mounted compact fluorescents and incandescents for ambient light. Low and line voltage halogen track is placed to accent many architectural features and highlight corridors. Linear fluorescents are used in many spaces including the classroom, rehearsal room, shop, work room and offices.

ASHRAE/IESNA 90.1 Shutoff Requirements

The ASHRAE/IESNA 90.1 shutoff requirements not fulfilled in the theatre. This is because there are not many spaces which it would be applicable. When the theatre is in use, the spaces being occupied are turned on. During the day, only the office areas and ambient lobby lighting are on.

Power Factor Correction

There is no power factor correction in the theatre.

Important Design Requirements

For the electrical design of the theatre, there were a few important design requirements. The equipment on the main distribution panels was split between the (2) 2000 A switchboards according to the noise level. The mechanical equipment was put on one panel and the lighting/dimming/receptacles were put on the other. The transformer is an isolation transformer to filter incoming noise. It is also a K-13 rated transformer which is rated for harmonic distortion. This transformer is isolating audio visual equipment, yet they do not produce harmonics.

Transformer Configuration

In the theatre, there is only one transformer. It is located in the shop where scenery for shows is built and stored. It is a step down transformer to step from 208 volts to a 208Y/120 system. The transformer is K-13 rated for harmonics and is an isolation transformer. It is mounted to a vibration isolation pad. Running from this transformer are an 100 A audio visual company switch and panel TP. This panel controls audio equipment and the control booth.

INDIVIDUAL TRANSFORMER SCHEDULE								
TAG	PRIMARY VOLTAGE	SECONDARY VOLTAGE	SIZE	TYPE	TEMP. RISE	TAPS	MOUNTING	REMARKS
T-1	208 V, 3PH, 3W	208Y/120V, 3PH, 4W	75	DRY TYPE	115 DEG. C	(6) 2.5%	PAD MOUNTED ON FLOOR	K-13 RATED

Primary Lamps and Ballasts

The following table is a schedule of the lamp specifications. For the full luminaire schedule see Tech Report 1. The actual ballast information was unknown. According to the specifications, the power factor for all ballasts used in the theatre must be >92%. The ballast factor for all ballasts used must be >96%. Therefore the power factor and ballast factor was assumed to be 0.93 and 0.97. Advance transformer ballasts were used for input watts and current.

LAMP AND BALLAST SCHEDULE						
FIXTURE TYPE	(NUMBER) LAMP TYPE	INPUT WATTS	POWER FACTOR	BALLAST FACTOR	CURRENT	VOLTS
A	100A 130V	100	N/A	N/A	0.83	120
A1	CF23EL/TWIST	23	N/A	N/A	0.19	120
A2	CF23EL/TWIST	23	N/A	N/A	0.19	120
A3	100A 130V	100	N/A	N/A	0.83	120
B	(2) 60PAR/HIR/FL4	120	N/A	N/A	1	120
B1	60PAR/HIR/FL40	60	N/A	N/A	0.5	120
B2	50PAR20/FL/25	50	N/A	N/A	0.42	120
B3	60 PAR/HIR/SP10 + 60PAR/HIR/FL40/XL	120	N/A	N/A	1	120
C	Q250PAR/FL30	250	N/A	N/A	2.08	120
C1	90PAR/HIR/FL40/XL	90	N/A	N/A	0.75	120
D3	60PAR/HIR/FL40	60	N/A	N/A	0.5	120
E1	Q50MR16/C/NSP15	50	N/A	N/A	0.42	12/120
E2	50AR111/SSP4	50	N/A	N/A	0.42	12/120
F	(2) FP28/830	60	0.93	0.97	0.54	120
F1	CF26DT/E/IN/830	32	0.93	0.97	0.29	120
F2	F32T8/SPX30	30	0.93	0.97	0.27	120
F3	CF26DT/E/IN/830	32	0.93	0.97	0.29	120

F5	(2) F32T8/SPX30	59	0.93	0.97	0.53	120
F6	(2) F32T8/SPX30	59	0.93	0.97	0.53	120
F7	(3)FBO32/830		0.93	0.97		120
F8	FP13/830	14	0.93	0.97	0.13	120
F9	(4)F32T8/SPX30	(2) 59	0.93	0.97	1.06	120
G	Q50MR16/C/NFL255	50	N/A	N/A	0.42	120
H	HPL/575X		N/A	N/A		120
J	Q35T3/12V/CL		N/A	N/A	0.29	12/120
K	40G25/W		N/A	N/A		120
L1	100PAR/HIR/FL40/XL	100	N/A	N/A	0.83	120
L2	100PAR/HIR/FL40/XL	100	N/A	N/A	0.83	120
L3	Q250PAR/FL30	250	N/A	N/A	2.08	120
L4	45PAR/HIR/FL40XL	45	N/A	N/A	0.375	120
N1	100PAR/HIR/SP10/XL	100	N/A	N/A	0.83	120
P	Q10T3/CL		N/A	N/A	0.08	12/120

NEC Load Calculation

Mechanical Loads

The following table contains the mechanical load information take from the mechanical schedule included in the drawings and the panelboards. If KVAs were not given on the panelboards, they were calculated from the HP or KW.

MECHANICAL EQUIPMENT SCHEDULE					
DESIGNATION	**UNIT SERVICES**	**VOLT**	**PHASE**	**HP or KW**	**KVA**
AIR HANDLING UNITS					
AHU-1/ HORIZONTAL	THEATER/ STAGE	208	3	15 HP SUPPLY 7.5 HP RETURN	25.5
AHU-2/ HORIZONTAL	BACK OF HOUSE	208	3	15 HP	16.5
AHU-3/ HORIZONTAL	STAGE WORKSHOP	208	3	5 HP	6
AHU-4/ VERTICAL	UPPER LOBBY	208	3	3 HP	4.8
AHU-5/ VERTICAL	LOWER LOBBY	208	3	2 HP	3
AHU-6/ VERTICAL	2ND LEVEL OFFICE SUITE	208	3	3 HP	3.9
AHU-7/ VERTICAL	2ND LEVEL MEETING ROOM	208	3	1 HP	1.8
AHU-8/ HORIZONTAL	WORK SHOP	208	3	2 HP	3

AHU-9/ HORIZONTAL	DIMMER CLOSET	208	3	0.75 HP	0.83
AHU-10/ HORIZONTAL	AV CLOSET	208	3	0.75 HP	0.83
FANS					
F-1	SMOKE EVAC	208	3	15 HP	16.7
F-2	O.A. MAKE-UP	208	3	15 HP	16.7
F-3	WELDING EXHAUST	208	3	5 HP	6
F-4	GENERAL EXHAUST	208	3	0.75 HP	3
F-5	2ND LEVEL COMPUTER ROOM	120	1	350 W	0.4
F-6	DRYER FAN	120	1	172 W	0.7
F-7	TOILET ROOMS	208	3	2 HP	3.9
F-8	DRYER BOOSTER FAN	120	1	87 W	0.1
F-9	DRYER BOOSTER FAN	120	1	87 W	0.1
F-10	O.A. BOOSTER FAN	120	1	455 W	0.1
F-11&-12	REFRIGERATOR FAN	120	1	455 W	0
F-13&14	ELEVATOR MACHINE RMS	120	1	172 W	0.8
PUMPS					
P-1	AHU'S	208	3	5 HP	12
P-2	STAND BY	208	3	5 HP	12
ELECTRIC HEATING COILS					
DH-1		208	3	15 KW	15
DH-2		208	3	50 KW	33.4
DH-3		208	3	20 KW	20.1
DH-4		208	3	10 KW	8.1
DH-5		208	3	25 KW	24.9
DH-6		208	3	10 KW	9.9
MISCELLANEOUS					
DC-1		208	3	7.5 HP	9
WH-1		208	3	4.5 KW	5
WH-2		208	3	54 KW	108
CH-1		208	3		153.3
				TOTAL KVA	**525.36**
	DEMAND FACTOR IS 0.5 ON THE LARGEST MOTOR			**TOTAL KVA WITH DEMAND**	**448.71**

Lighting Loads

The following table is the lighting loads for the theatre. They were calculated by the space-by-space method and occupancy type. The unit loads are from the National Electric Code 2005 Table 220.12 General Lighting Loads By Occupancy.

OCCUPANCY TYPE	DEMAND FACTOR (VA/SF)	1ST FLOOR		2ND FLOOR		3RD FLOOR		TOTAL DEMAND KVA
		AREA	DEMAND KVA	AREA	DEMAND KVA	AREA	DEMAND KVA	
CLASSROOM	3	660	1.98		0		0	1.98
REHEARSAL ROOM	1	1835	1.835		0		0	1.835
LOBBY	1	2743	2.743	2345	2.345	301	0.301	5.389
OFFICE	3.5	1033	3.6155		0	2563	8.9705	12.586
STORAGE/ MECHANICAL	0.25	1681	0.42025	169	0.04225	173	0.04325	0.50575
CORRIDOR/ CLOSETS	0.5	2423	1.2115	271	0.1355	247	0.1235	1.4705
THEATRE	1	4412	4.412	1632	1.632		0	6.044
RESTROOMS/ DRESSING	2	2034	4.068	119	0.238	53	0.106	4.412
WORK ROOMS/ SHOP	2	3801	7.602		0		0	7.602
MULTI-PURPOSE	1	1046	1.046		0	412	0.412	1.458
							Total KVA	43.28
							NO DEMAND FACTOR WAS APPLIED	

Receptacles

The following table is the total connected receptacle load in the theatre. This was found by summing all receptacle loads on the panelboards. All receptacles are rated at 20 A.

TOTAL CONNECTED GENERAL RECEPTACLE LOAD	86.1 KVA
There are no emergency receptacles.	
DEMAND FACTOR	**Load KVA**
1.0 for the first 10 KVA general use receptacles	10
0.5 for the remaing KVA general use receptacles	38.05
	48.05
	TOTAL KVA WITH DEMAND

Elevator

The following table is the total connected elevator load in the theatre.

EQUIPMENT	KVA	
ELEVATOR	27	
FREIGHT ELEVATOR	36	
	63	**TOTAL KVA**
	NO DEMAND FACTOR WAS APPLIED	

Total Load

LOAD TYPE	DEMAND LOAD (KVA)
LIGHTING	43.28
MECHANICAL	448.71
RECEPTACLE	48.05
ELEVATOR	63
	603.04
	TOTAL KVA CONNECTED LOAD

Sizing the System

Main Distribution Panels

There are two main distribution panels in the theatre. Panel S1 is the distribution panel for the lighting and receptacle loads in the building. Panel S2 is the distribution panel for the mechanical and elevator loads. The actual lighting load was not calculated. The unit load will be used for this sizing. Other loads not included in this calculation are audio and visual equipment, systems furniture and theatre stage lighting,

Panel S1

Connected KVA:	91.33
Connected Amps:	91.33 KVA / (1.732*0.208) = 253.70 A
25% Growth:	317.12 A
	2000 A >> 317.12 A

Panel S2

Connected KVA:	511.71
Connected Amps:	511.71 KVA / (1.732*0.208) = 1421.42 A
25% Growth:	1776.77 A
	2000 A > 1776.77 A

Both main distribution panels are sized adequately. There is room for growth in both cases.

Feeder Sizing

There are fifteen main feeders running from the main distribution panels to other panels and equipment in the system. These fifteen feeders were checked for their sizing and circuit breakers. Alls wires assumed to be typical 75 degree copper wires.

Feeder 1

Connected KVA:	55.4
Connected Amps:	55.4 KVA / (1.732*0.208) = 153.78 A
25% Growth:	192.2 A
Wire Sizing:	500 KCMIL is rated at 380 A
Ckt Bkr:	400 A ckt. bkr.

Feeder 2

Connected KVA:	30.1 + 79.6 = 105.4
Connected Amps:	109.7 KVA / (1.732*0.208) = 304.51 A
25% Growth:	380.6 A
Wire Sizing:	500 KCMIL is rated at 380 A
Ckt Bkr:	400 A ckt. bkr.

Feeder 3

Connected KVA:	34.1
Connected Amps:	34.1 KVA / (1.732*0.208) = 94.72 A
25% Growth:	118.40 A
Wire Sizing:	4/0 is rated at 230 A
Ckt Bkr:	225 A ckt. bkr.

Feeder 4

Connected KVA:	35.9 + 100 A for Audio Equipment
Connected Amps:	35.9 KVA / (1.732*0.208) = 99.72 + 100 = 199.72 A
25% Growth:	249.65 A
Wire Sizing:	250 KCMIL is rated at 255 A
Ckt Bkr:	225 A ckt. bkr.

Feeder 5

Connected KVA:	11.2
Connected Amps:	11.2 KVA / (1.732*0.208) = 99.72 + 100 = 31.11 A
25% Growth:	38.89 A
Wire Sizing:	#1 is rated at 130 A
Ckt Bkr:	225 A ckt. bkr.

Feeder 6

Connected KVA:	22
Connected Amps:	22 KVA / (1.732*0.208) = 61.11 A
25% Growth:	76.39 A
Wire Sizing:	500 KCMIL is rated at 380 A
Ckt Bkr:	400 A ckt. bkr.

Feeder 7

Connected KVA:	173
Connected Amps:	173 KVA / (1.732*0.208) = 480.56 A
25% Growth:	600.70 A
Wire Sizing:	(2 sets) 400 KCMIL is rated at 670 A
Ckt Bkr:	600 A ckt. bkr.

Feeder 8

Connected KVA:	173
Connected Amps:	173 KVA / (1.732*0.208) = 480.56 A
25% Growth:	600.70 A
Wire Sizing:	(2 sets) 400 KCMIL is rated at 670 A
Ckt Bkr:	600 A ckt. bkr.

Feeder 9

Connected KVA:	79.5
Connected Amps:	79.5 KVA / (1.732*0.208) = 220.83 A
25% Growth:	276.04 A
Wire Sizing:	500 KCMIL is rated at 380 A
Ckt Bkr:	400 A ckt. bkr.

Feeder 10

Connected KVA:	153.3
Connected Amps:	153.3 KVA / (1.732*0.208) = 425.83 A
25% Growth:	532.29 A
Wire Sizing:	(2 sets) 250 KCMIL is rated at 510 A
Ckt Bkr:	550 A ckt. bkr.

Feeder 11

Connected KVA:	27
Connected Amps:	27 KVA / (1.732*0.208) = 75 A
25% Growth:	93.75 A
Wire Sizing:	#1 is rated at 130 A
Ckt Bkr:	150 A ckt. bkr.

Feeder 12

Connected KVA:	36
Connected Amps:	36 KVA / (1.732*0.208) = 100 A
25% Growth:	125 A
Wire Sizing:	1/0 is rated at 150 A
Ckt Bkr:	200 A ckt. bkr.

Feeder 13

Connected KVA:	54
Connected Amps:	54 KVA / (1.732*0.208) = 150 A
25% Growth:	187.50 A
Wire Sizing:	3/0 is rated at 200 A
Ckt Bkr:	200 A ckt. bkr.

Feeder 14

Connected KVA:	54
Connected Amps:	54 KVA / (1.732*0.208) = 150 A
25% Growth:	187.50 A
Wire Sizing:	3/0 is rated at 200 A
Ckt Bkr:	200 A ckt. bkr.

Feeder 15

Connected KVA:	79.5
Connected Amps:	79.5 KVA / (1.732*0.208) = 220.83 A
25% Growth:	276.04 A
Wire Sizing:	500 KCMIL is rated at 380 A
Ckt Bkr:	400 A ckt. bkr.

All above feeders are sized adequately. Some of the feeders are oversized to take voltage drop into account.

Utility Rate Structure

The following table displays the utility rate structure from the Potomac Electric Company for the past year. The administrative credit and procurement cost adjustment charges for each month can be found online at http://www.pepco.com/home/choice/dc/rates/.

	July 2005- October 2005	November 2005- May 2006	June 2006- July 2006
Distribution Services			
On-Peak Energy	0.01029 per kwh	0.01029 per kwh	0.01029 per kwh
Int-Peak Energy	0.01029 per kwh	0.01029 per kwh	0.01029 per kwh
Off-Peak Energy	0.01029 per kwh	0.01029 per kwh	0.01029 per kwh
Reliability Energy Trust Fund	0.00065 per kwh	0.00065 per kwh	0.00065 per kwh
Public Space Occupancy Surcharge	0.00159 per kwh	0.00159 per kwh	0.00154 per kwh
Delivery Tax	0.00770 per kwh	0.00770 per kwh	0.00770 per kwh
Administrative Credit	http://www.pepco.com/home/choice/dc/rates/		
Generation Services			
On-Peak Energy	0.08682 per kwh	0.06889 per kwh	0.11547 per kwh
Int-Peak Energy	0.06632 per kwh	0.07239 per kwh	0.10856 per kwh
Off-Peak Energy	0.05645 per kwh	0.05757 per kwh	0.09700 per kwh
Procurement Cost Adjustment	http://www.pepco.com/home/choice/dc/rates/		
Transmission Services			
On-Peak Energy	0.00111 per kwh	0.00111 per kwh	0.00111 per kwh
Int-Peak Energy	0.00111 per kwh	0.00111 per kwh	0.00111 per kwh
Off-Peak Energy	0.00111 per kwh	0.00111 per kwh	0.00111 per kwh

Power Consumption and Maximum Demand Load

The following table displays the power consumption in KWH for the past year. It also displays the maximum demand load in KW for the past year.

		Power Consumption (KWH)	Maximum Demand Load (KW)
2005	July	84,000	240
	August	71,400	192
	September	79,800	180
	October	58,800	162
	November	85,200	198
	December	93,600	204
2006	January	72,000	192
	February	85,200	186
	March	73,200	180
	Aprill	87,000	204
	May	82,200	174
	June	75,600	198
	July	93,600	192

The existing available service entrance load is unknown. Therefore the capacity of the service entrance being used on a monthly basis was not calculated. This information is in the process of being found out.

Communication Systems

Fire Alarm

The fire alarm system has many different components. Some of them include speakers, smoke detectors, heat detectors, manual pull station, strobe lights and door holders. There are combination fire alarm signaling devices with ADA strobe lights in all public areas. In addition, many of these areas include smoke detectors and extra ADA strobe lights. Manual pull stations are located in the lobby and A/V room. Fire alarm interface devices are connected to the air handling units and the audio visual panel (TP).

Telephone/ Data

The telephone and data communication system is run throughout the building. The most important parts of this system are the telephone, fax and internet. All of these are needed in most spaces including all offices, lobby, work rooms and wardrobe.

Audio Visual

The audio visual equipment is run from the isolation transformer located in the shop. From this transformer, a company disconnect switch is connected, along with panel TP. The equipment on this panel includes speakers, ceiling and wall panels, volume controls, speaker and video outputs, and junction boxes. There are ceiling speakers run throughout the corridors, bathrooms, dressing rooms, wardrobe and offices on the first floor. In the lobby on the first and second floors there are wall speakers.