



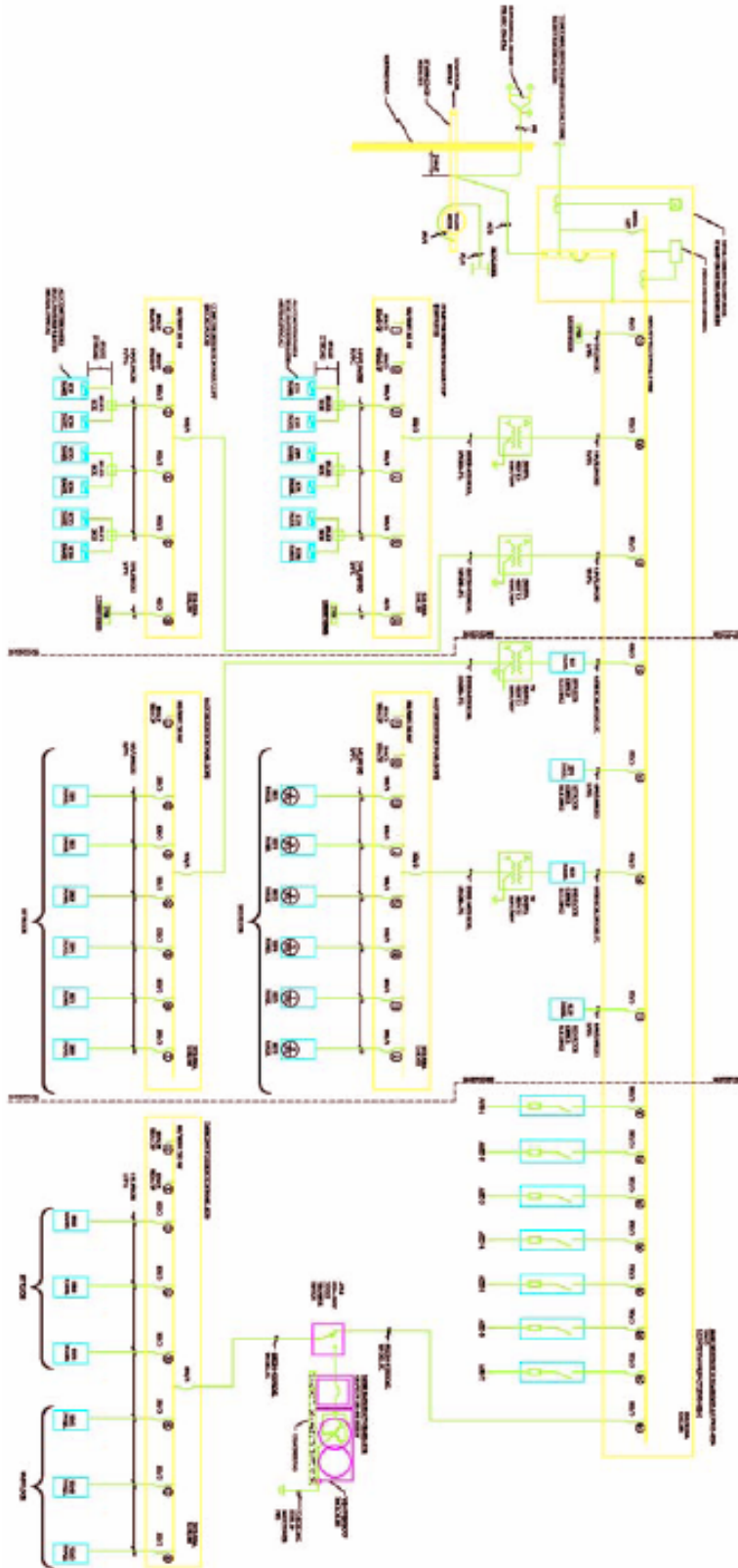
8. Electrical Analysis

Electrical Analysis

The AstroPower Headquarters building was constructed a few years ago to act as both a Headquarters and to be a display of what the product they manufacture can accomplish when put to work. The building features both office and manufacturing areas, requiring ample power in both spaces to attend to the research and professional sides of their corporation. The electrical system for a building like this must be designed to suit the use of the building, and also be able to provide flexibility for future additions the building might encounter. This report will go into the different aspects of the existing electrical system while providing information related to power usage, power distribution throughout the building, and other electrical load calculations.

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Part I – Single Line Diagram



(A magnified version of the Single Line Diagram can be found in the Appendix)

Part II – Electrical Systems Existing Conditions

The following is a compilation of information pertaining to the building electrical system that currently exists in the AstroPower Headquarters building.

System Type

The AstroPower Headquarters building features a Load-center system using radial-type circuit arrangement. This design allows the power to be distributed at the highest economical voltage level to areas of concentrated load where the voltage is transferred down to the utilization level. The utilization equipment is then supplied using relatively short low-voltage feeders.

The load-center type of distribution has been made possible by the development of drytype medium-voltage switchgear and transformers that do not require expensive fireproof vaults and by the development of lower-cost medium-voltage feeder cables. The primary distribution switchgear is the metal-clad type using medium-voltage air circuit breakers.

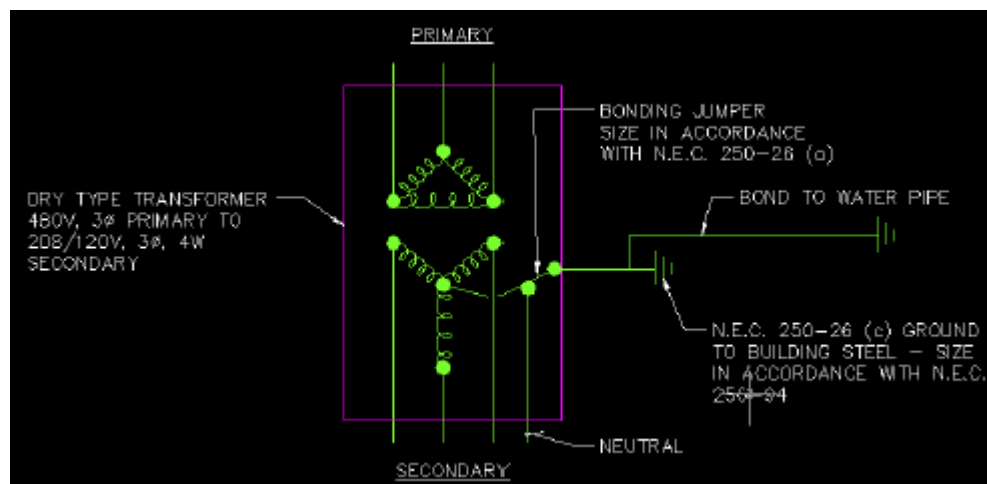
Building Utilization Voltage

Incoming electrical power is provided at 12kV, which is then transferred into 480Y/277V to be distributed to the different distribution panels and air handling units for the lighting and mechanical systems. The lines are transferred again into 120/208V for receptacles and other power loads.

Transformer Configuration

All transformers used in the electrical distribution system are dry energy saving units square “D” T3HB series. The

transformers convert three phase, three wire 460 volt delta primary to three phase, four wire 208/120V grounded wye secondary. The transformers also have a 220° insulation and 80° rise temperature



rating, with 2 ½ % FCAN and 4 – 2 ½ % FCBN taps. For the computer distribution panels the TC-1 transformers are used. They are K-rated, electrostatically shielded, square D and Class 7400.

Emergency Power Systems

Emergency power in the AstroPower Headquarters is provided by a Diesel Emergency Generator located outside the building. It is underneath a weatherproof enclosure and on top of a concrete pad. The generator is a 480/277V three phase, four wire system that provides 200 kilowatts of power. When the Emergency Generator is not in use, the Emergency Distribution panel is powered by a line coming in from the Main Distribution Board. Upon power shut down, a three pole transfer switch connects to the generator providing 600 volts to the Emergency Distribution panel. This panel is equipped with 120/208V, three phase four wire connections to power the emergency lighting, exhaust fans, and other equipment located in the building.

Over-current Protective Devices

The AstroPower Headquarters uses several measures for over-current protection. After the transformer steps down the power from 12 kV to 480/277V, circuit breakers are located on each line out to the individual distribution panels. On the main distribution board, the circuit breakers are listed as three pole 80, 125, 200, 225, 400, or 600 amp circuit breakers. On the computer distribution panels, three pole 200 amp and 40 amp circuit breakers are used. On the main distribution panels, three pole 100 amp circuit breakers are used. Finally, the emergency distribution panel uses three pole 100 amp circuit breakers.

The air handling units are equipped with fuses and fused switches. They lead off the main distribution board with three pole 225 amps circuit breakers. There are a total of seven air handling units.

Finally, off of the main distribution board and the two computer distribution panels there are Liberty Interceptor series transient voltage surge suppressors. They lead off the main lines with three pole 40 amp circuit breakers. With these protective devices, any type of damage will hopefully be prevented.

Location of Electrical Rooms and Equipment

A main electrical room, number 154, is located between columns L and M and line six, on the first floor in the office area. It is approximately twenty feet deep by eight feet wide. The room has the following panels and equipment: two 150kVA transformers, a security panel, and emergency distribution panel, a fire alarm panel, a 600A transfer switch, along with the panels 1EM1, 1EM2, 1CP1, 1CP2, 1CP3, 1RP1, 1RP2, 1RP3, MDP1, 1LP1, and CDP.

A secondary electrical room, number 174, is located between columns K and L and line three, on the first floor in the office area. It is approximately ten feet deep by six feet wide. The room has the following panels: 1LP2, 1RP4, 1RP5, 1RP6, 1CP4, 1CP5, 1CP6, 1EM3.

Another main electrical room, number 244, is located between columns L and M and line six, on the second floor in the office area. It is approximately sixteen feet deep by eight feet wide. The room has the following panels and equipment: two 150kVA transformers, along with panels 2EM1, 2EM2, 2CP1, 2CP2, 2CP3, CDP2, 2RP1, 2RP2, 2RP3, MDP2, and 2LP1.

Another secondary electrical room, number 272, is located between columns K and L and line three, on the second floor in the office area. It is approximately ten feet deep by six feet wide. The room has the following panels: 2LP2, 2RP4, 2RP5, 2RP6, 2CP4, 2CP5, 2CP6, and 2EM3.

Typical Lighting Systems

The lighting used in the AstroPower Headquarters is categorized as being fluorescent and L.E.D. All fluorescent and L.E.D. fixtures in the building are to have an input of 277V and a frequency of 60 Hz. The THD shall be less than 20% for the main lamp design, and the Lamp Current Crest factor shall not exceed 1.7. The power factor must be greater than 98%, but for most lamps is assumed to be 1.0. For the fluorescent fixtures, the ballasts must be CSA approved and UL listed class P.

Important Design Requirements

Since two of the four electrical panels feed the computer areas, a Leibert Interceptor Series transient voltage surge suppressor is connected. There is also one off the main line on the main distribution board after the transformer steps down the 12kV line in. There are also four additional transformers from the main distribution board to the four other panels that step down the voltage from 150 kVA 480V to 208Y/120V.

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Part III – Lighting and Mechanical Systems Information

The following tables list the primary lamps and ballasts that are used in the AstroPower Headquarters building:

Lamps

Fixture	Manufacturer	Model	Feature	Watts	Bulb	Base	CRI	CCT	Des. Lumens	Init. Lumens
A	Philips Lighting	SILHOUTTE™ Programmed Start	T5 Miniature Bipin Fluorescent Lamps	28	T5	Min. Bipin	85	4100 K	2750	2900
B	Philips Lighting	SILHOUTTE™ High Output Prog. Start	T5 Miniature Bipin Fluorescent Lamps	24	T5	Min. Bipin	85	4100 K	1895	2000
C	Philips Lighting	PL-T Triple 4-Pin Fluorescent Lamp	ALTO® Lamp Technology	18	PL-T	GX24q-2	82	4100 K	1020	1200
D	Philips Lighting	MasterColor® Tubular Single-Ended T-4	Lifetime Color Stability	39	T-4	G8.5	N/A	N/A	2640	3300
E	Philips Lighting	PL-T Triple 4-Pin Fluorescent Lamp	ALTO® Lamp Technology	26	PL-T	GX24q-3	82	4100 K	1530	1800
F	Philips Lighting	ALTO® SILHOUTTE™ High Output Prog. Start	T5 Miniature Bipin Fluorescent Lamps	54	T5	Min. Bipin	85	4100 K	4750	5000
G	Philips Lighting	PL-T Triple 4-Pin Fluorescent Lamp	ALTO® Lamp Technology	32	PL-T	GX24q-3	82	4100 K	2040	2400
H	Philips Lighting	PL-T Triple 4-Pin Fluorescent Lamp	ALTO® Outdoor Lamp Technology	18	PL-T	GX24q-2	82	4100 K	1020	1200

Ballasts

Fixture	Manufacturer	Model	Brand Name	Type	Starting Method	Volts	Frequency	Input Power	Ballast Factor	Power Factor
A	Advance	VCN-132-MC	CENTIUM	Electronic	Instant Start	277	60	30 W	0.98	0.99
B	Advance	ICN-2S24@277V	CENTIUM	Electronic	Prog. Start	277	50/60	52 W	1	0.98
C	Advance	ICF-2S18-M1-BS@277	ADVANCE CFL	Electronic	Prog. Start	120-277	50/60	20 W	1.05	0.98
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	Advance	ICF-2S26-H1-LD@120	ADVANCE CFL	Electronic	Prog. Start	120-277	50/60	29 W	1.1	0.98
F	Advance	ICN-2S54-90C@277	CENTIUM	Electronic	Prog. Start	277	50/60	62 W	1.02	0.98
G	Advance	ICF-2S24-M2-BS@120	ADVANCE CFL	Electronic	Prog. Start	120-277	50/60	68 W	0.98	0.98
H	Advance	ICF-2S18-H1-LD@120	ADVANCE CFL	Electronic	Prog. Start	120-277	50/60	20 W	1.05	0.98

The following tables list the mechanical equipment that is used in the AstroPower Headquarters building:

Roof Top Units

Symbol	Description	Tot CFM	Min. O.A. CFM	Net Cooling Capacity	Mixed Air Ent		Capacity (MBH)		Net Heating Capacity			Power V/PH/Hz
				Amb DB Temp	DB	WB	Tot	Sens	Ent. Air Temp	Input (MBH)	Output (MBH)	
RTU-1	1FI Perim	12,000	1020	93	76.5	64	361	328	69.5	500	240	460/3/60
RTU-2	1FINorth	12,000	1520	93	77.3	64.5	360	292	66.8	500	170	460/3/60
RTU-3	2FINorth	16,000	1520	93	76.7	64.1	436	395	68.8	850	216	460/3/60
RTU-4	2FISouth	16,000	1520	93	76.7	64.1	436	395	68.8	850	216	460/3/60
RTU-5	1FISouth	12,000	1520	93	77.3	64.5	360	292	66.8	500	170	460/3/60
RTU-6	2FI Perim	14,000	1020	93	76.3	63.9	436	395	70.3	500	224	460/3/60
RTU-7	Air Hand Unit	30,000	7,500	93	81.8	67.5	920	465	56.5	-	410	460/3/60
RTU-8	Air Hand Unit	30,000	7,500	93	81.8	67.5	920	465	56.5	-	410	460/3/60
RTU-9	Air Hand Unit	30,000	7,500	93	81.8	67.5	920	465	56.5	-	410	460/3/60
RTU-10	Air Hand Unit	30,000	7,500	93	81.8	67.5	920	465	56.5	-	410	460/3/60
RTU-11	Air Hand Unit	30,000	7,500	93	81.8	67.5	920	465	56.5	-	410	460/3/60
RTU-12	Air Hand Unit	30,000	7,500	93	81.8	67.5	920	465	56.5	-	410	460/3/60
RTU-13	Air Hand Unit	30,000	7,500	93	81.8	67.5	920	465	56.5	-	410	460/3/60
RTU-14	Air Hand Unit	30,000	7,500	93	81.8	67.5	920	465	56.5	-	410	460/3/60

Symbol	Basis
RTU-1	Trane SFHFC40P, 40 ton nom.
RTU-2	Trane SFHFC40P, 40 ton nom.
RTU-3	Trane SFHFC40P, 40 ton nom.
RTU-4	Trane SFHFC40P, 40 ton nom.
RTU-5	Trane SFHFC40P, 40 ton nom.
RTU-6	Trane SFHFC40P, 40 ton nom.
RTU-7	Trane SFHFC75P, 75 ton nom.
RTU-8	Trane SFHFC75P, 75 ton nom.
RTU-9	Trane SFHFC75P, 75 ton nom.
RTU-10	Trane SFHFC75P, 75 ton nom.
RTU-11	Trane SFHFC75P, 75 ton nom.
RTU-12	Trane SFHFC75P, 75 ton nom.
RTU-13	Trane SFHFC75P, 75 ton nom.
RTU-14	Trane SFHFC75P, 75 ton nom.

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Exhaust Fans

Symbol	Description	Location	CFM	ESP	Fan R.P.M.	Motor H.P.	Sones	V/PH/Hz	Basis
EF-1	1Fl. Core	Roof	1800	15	1445	1	13.9	208/3/60	Penn Ventilator Domex DX14B
EF-2	2Fl. Core	Roof	1000	1	1282	0.5	9.6	208/3/60	Penn Ventilator Domex DX11B
EF-3	Machine Rm.	Roof	400	1	1225	0.25	9.1	115/1/60	Penn Ventilator Domex DX11B
EF-4	Elec. RMS	Roof	400	1	1225	0.25	9.1	115/1/60	Penn Ventilator Domex DX11B
EF-5	Elec. RMS	Roof	400	1	1225	0.25	9.1	115/1/60	Penn Ventilator Domex DX11B

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Part IV – Building Load Calculations

The total building loads were tabulated for the AstroPower Headquarters building. Listed below are the total loads from the lighting and receptacle load. The mechanical load has not been included in the final building total.

Receptacle Load

Location	Square Feet	Number of Receptacles
Warehouse	100,909	2,019
Office - Fl. 1	29,645	593
Office - Fl. 2	29,563	589
Total Number of Receptacles		3,201
x 180 VA / Receptacle =		x 180
Receptacle Load (VA)		576,180
First 10,000 VA at 100%		10,000
Remaining 566,180 at 50%		283,090
TOTAL Computed Load (VA)		293,090
(kVA)		293.09

Total Receptacle Load = 293,090 = **293.03 kVA**

Lighting Load

Data taken from NEC 2002 Table 220-3(a) General Lighting Load by occupancy:

Warehouse/Manufacturing: 100,909 ft.² x 2 VA = **201,818 VA**

Office Area: 59,208 ft.² x 3 ½ VA = **207,228 VA**

Total Lighting Load = 409,046 VA = **409.046 kVA**

Demand Factor

Data taken from NEC 2002 Table 220-11 Lighting Load Demand Factors:

All Others – Total volt-amperes = 100%

Total Building Load (for Lighting and Receptacles)

The total building load for Lighting and Receptacles (excluding Mechanical) is **702.136 kVA**.