IEEE-IAS Atlanta Section

CH2MHILL®

Electrical Drawing Preparation
Single Lines and Grounding Plans



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Electrical Drawing Preparation
Single Lines

Electrical Drawing Preparation
Single Lines

- INPUTS:
  - P&ID's
  - Load List
  - Distribution Philosophy
  - Basis of Design
  - Layout Drawings

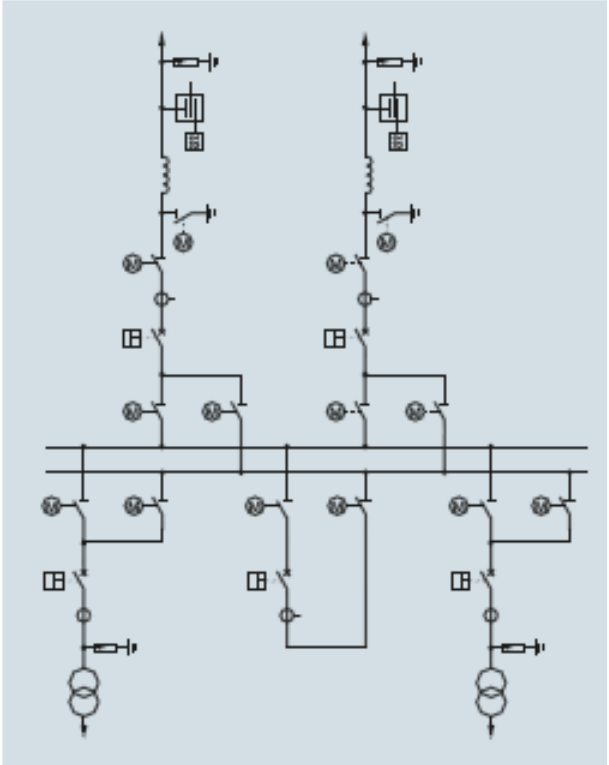
Electrical Drawing Preparation
Single Lines

- P&ID's
  - Process Motor Loads
  - Process Heater Loads
  - Heat Tracing
- Load List
  - Non- Process Motors
    - HVAC
    - Air Compressors / Vacuum Pumps
  - Lighting
    - Indoor
    - Outdoor
  - UPS for Communications / Security / Fire Alarm

Switchboard No.	Voltage	Source	Total Demand				Continuous Load						Intermittent Load						Spare Load			
	(kV)	Bus No.	kW	kvar	kVA	PF (%)	kW	kvar	kVA	PF (%)	CF (%)	CF x kVA	kW	kvar	kVA	PF (%)	CF (%)	CF x kVA	kW	kvar	kVA	PF (%)
SG-01	13.8	< top >	8441	3988	9336	90.4	8750	4119	9671	90.5	92.0	8897	47	31	56	83.7	30.0	17	2516	1285	2816	89.3
MC-02	4.16	SG-02	1147	622	1305	87.9	1247	676	1418	87.9	92.0	1305					25.0					
MC-03	4.16	SG-02	795	401	891	89.1	830	421	931	89.2	92.0	856					25.0		212	135	251	84.4
SG-02	4.16	SG-01	6815	3198	7528	90.5	8316	3879	9176	90.6	75.0	6882	23	19	30	78.1			2310	1156	2583	89.4
EXISTING-A	0.48	SG-01									100.0						50.0					
EXISTING-B	0.48	SG-01									100.0						50.0					
MC-021	0.48	SG-02	71	47	85	83.6	64	41	76	84.4	86.0	66	23	19	30	78.1	42.0	13	40	24	47	85.5
MC-031	0.48	SG-01	174	105	203	85.5	191	116	223	85.5	91.0	203					33.0					
MC-041	0.48	SG-01	355	136	298	88.9	243	125	273	89.0	96.0	262	24	12	27	89.0	47.0	13	206	109	233	88.3
DP-01	0.24	MC-041	58	30	65	88.8	48	25	54	88.9	95.0	52	24	12	27	89.0	50.0	13	54	27	60	89.3

Electrical Drawing Preparation
Single Lines

- Distribution Philosophy
  - Voltage Level(s)
  - Distribution Scheme
  - Protection Scheme / Philosophy
  - Selectivity
- Basis of Design
  - Motor HP / Voltage Ranges
  - Motor Protection Philosophy
  - Lighting Voltage
- Layout Drawings
  - Location of Electrical Rooms & Transformers
  - Load Concentration(s)



Electrical Drawing Preparation
Single Lines

- Use the proper ABBREVIATIONS.
- Follow the LEGEND sheet.
- Don’t mix ANSI and IEC symbols for the same item type.
- Proper TERMINOLOGY (Ratings, Equipment)
- Indicate FUTURE expansion capability.
- Indicate normal operational mode (OPEN/ CLOSE) for all switching devices
- Provide a front VIEW.

Electrical Drawing Preparation
Single Lines (IEEE 141-1993)

Include the following:

- Utility Supply System
  - Available SC current (including X/R ratio)
  - Line supply voltage
  - High-voltage protective devices and switches
  - Show the normal operating mode
  - Type(s) of relays

Electrical Drawing Preparation
Single Lines (IEEE 141-1993)

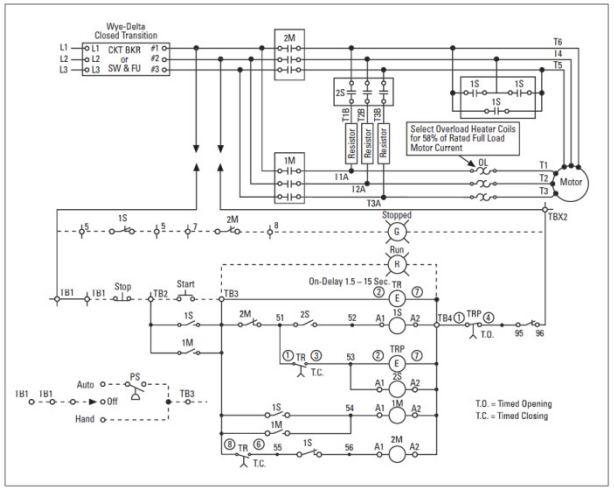
- Transformers
  - Nameplate rating(s) (kVA and kV) and temperature rise
  - Cooling Method (ONAN, ONAF {AA, FA})
  - High-voltage winding voltage taps and winding connection (delta/wye)
  - Low-voltage winding voltage taps and winding connection (delta/wye)
  - Impedance and kVA base
  - Grounding scheme and ohmic value of neutral resistor(s) if used; show connections
  - Surge arrestors and capacitors (show switching if switched), and connections
  - Metering of utility supply, primary protective devices

Electrical Drawing Preparation
Single Lines (IEEE 141-1993)

- Switchgear
  - Manufacturer(s), type, model, current rating, MVA class
  - Symmetrical interrupting current rating, and asymmetrical momentary/closing-and-latching current rating for main, tie, and feeder devices
  - Phase arrangement, voltage, ampacity, bracing of bus

Electrical Drawing Preparation
Single Lines (IEEE 141-1993)

- Motor loads
  - List individual medium-voltage motors including HP/KW, RPM, and type (induction, synchronous)
  - Include powerhouse motors (chillers, compressors, etc.)
  - LV motors on MCC's: Categorize load by size(s) at a minimum
  - Indicate all VFD motors, RV starters



Electrical Drawing Preparation
Single Lines (IEEE 141-1993)

- Feeder cables
  - Number of feeders
  - Cable insulation and type
  - Installation design (conduit, IAC in tray, size of tray, number of cables in tray, etc.)
  - Nominal maximum current rating and basis
  - Cable callouts are consistent

Electrical Drawing Preparation
Single Lines (IEEE 141-1993)

- Other
  - Dedicated lighting loads
  - Special purpose loads, such as data processing and computer applications
  - Capacitor banks, including switching
  - Relay coordination and protective-device settings (on separate documentation)
  - Standby Generators

Electrical Drawing Preparation
Grounding Plans

Electrical Drawing Preparation Grounding Plans

- INPUTS:
  - Basis of Design
  - Ground Resistance Data
  - Grounding Calculations
  - Layout Drawings
    - Process Equipment (Large Motors, Tanks)
    - Electrical Rooms
  - Structural Drawings
    - Foundations
    - Columns

20		20	34.6									

INVERSE MODELLING RESULTS FOR SOUNDINGS

Layered Inversion – Sounding A			Layered Inversion – Sounding B			Layered Inversion – Not Completed			Layered Inversion – Not Completed		
Layer No.	Depth (m)	Resistivity (Ω-m)	Layer No.	Depth (m)	Resistivity (Ω-m)	Layer No.	Depth (m)	Resistivity (Ω-m)	Layer No.	Depth (m)	Resistivity (Ω-m)
1	0.0	690.0	1	0.0	680.0						
2	3.9	55.2	2	3.1	54.7						

SUMMARY Average Resistivity	Layer No.	Depth (m)	Resistivity (Ω-m)
	1	0.0	685.0
	2	3.5	55.0

Site Photo:

Notes:	* Result at this electrode spacing not possible.
Site Observations:	Topography: Flat Weather: Fine

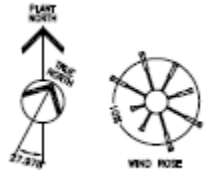
Ground Grid Summary Report

Rg Ground Resistance ohm	GPR Ground Potential Rise Volts	Maximum Touch Potential					Maximum Step Potential				
		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (m) X	Coordinates (m) Y	Tolerable Volts	Calculated Volts	Calculated %	Coordinates (m) X	Coordinates (m) Y
0.636	631.9	328.2	436.8	133.1	23.6	62.5	841.8	127.7	15.2	239.10	19.77

Total Fault Current	1.800 kA	Reflection Factor (K):	0.322
Maximum Grid Current:	0.994 kA	Surface Layer Derating Factor (Cs):	1.231
		Decrement Factor (Df):	1.001

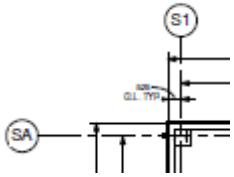
Electrical Drawing Preparation
Plan Drawings

- Overall Plan



  - North ARROW
  - SCALE: Consistent, include graphic bar

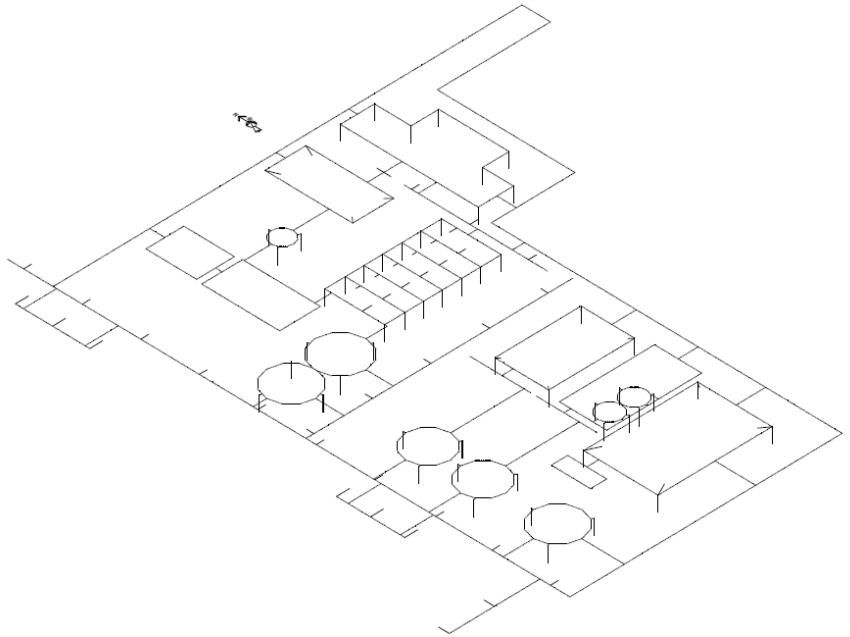
  - Match lines
  - Reference drawings
  - TITLE Block
  - Follow LEGEND Sheet
  - General notes: Generic to Specific
  - COLUMN line numbers



  - General arrangement of process equipment

Electrical Drawing Preparation
Grounding Plans

- Facility Ground System
  - Primary
    - Earth Electrode Subsystem
    - Fault Protection Subsystem
    - Lightning Protection Subsystem
    - Signal Reference Subsystem
  - Secondary
    - Static Protection
    - Cathodic Protection
    - Safety (Maintenance) Grounding



Grounding Plans
Facility Ground System

- Primary
  - Earth Electrode Subsystem

    network of interconnected rods, wires, pipes, or other configuration of metals which establishes electrical contact between the elements of the facility and the earth[1]

  - Fault Protection Subsystem

    ensures that personnel are protected from shock hazard and equipment is protected from damage or destruction resulting from faults that may develop in the electrical system[1]

Grounding Plans
Facility Ground System

- Primary
  - Lightning Protection Subsystem

    provides a nondestructive path to ground for lightning energy contacting or induced in facility structures[1]

  - Signal Reference Subsystem

    The purpose of a signal reference ground is to provide a low impedance signal reference system for electronic equipment to minimize noise-induced voltages and thereby reduce equipment malfunctions[2]

Grounding Plans
Facility Ground System

- Secondary
  - Static Protection

    static ground is a connection between a piece of equipment and earth to drain off static electricity charges before they reach a sparking potential[2]
  - Cathodic Protection

    Cathodic protection is a method to reduce corrosion by minimizing the difference in potential between anode and cathode.[3]
  - Safety (Maintenance) Grounding

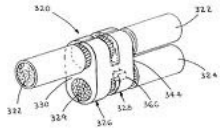
    Temporary grounding is provided to protect workers engaged in deenergized electric line maintenance.[4]

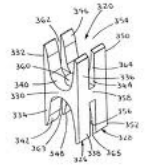
Electrical Drawing Preparation
Grounding Plans

- Facility Ground System
  - Primary
    - Earth Electrode Subsystem IEEE 142-2007 (Green Book)
    - Fault Protection Subsystem NFPA 70 (NEC®)
    - Lightning Protection Subsystem NFPA 780
    - Signal Reference Subsystem IEEE 1100-2005 (Emerald Book)
  - Secondary
    - Static Protection NFPA 77
    - Cathodic Protection NACE SP9999
    - Safety (Maintenance) Grounding NFPA 70E, IEEE C2

Electrical Drawing Preparation
Grounding Plans - Earth Electrodes

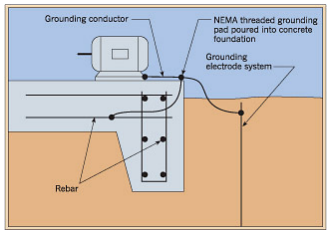
- IEEE 142-2007 (Green Book)
  - Chapter 4 Connection to earth
    - 4.1 Resistance to earth (Table 4-5—Formulas for the calculation of resistances to ground)
    - 4.2.3 Concrete encased electrodes
    - 4.3.1 Choice of rods
    - 4.3.3 Connecting to electrodes
    - 4.4 Measurement of resistance to earth
  - Chapter 1 System grounding
  - Chapter 2 Equipment grounding
  - Chapter 3 Static and lightning protection grounding
  - Chapter 5 Electronic equipment grounding





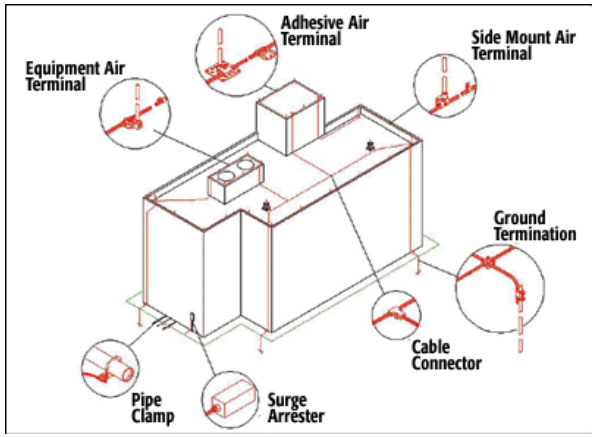
Electrical Drawing Preparation
Grounding Plans - Fault Protection

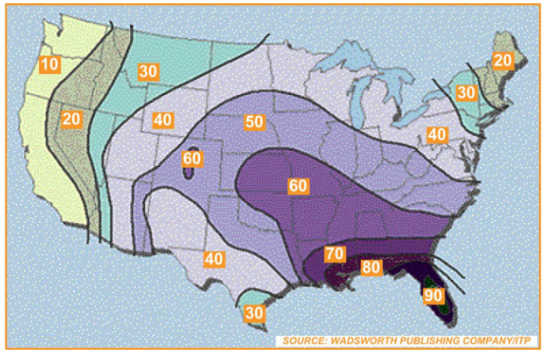
- NFPA 70 (NEC®) ARTICLE 250 Grounding and Bonding
  - II. System Grounding
    - 250.20 Alternating-Current Systems to Be Grounded
    - 250.24 Grounding Service-Supplied Alternating-Current Systems
    - 250.30 Grounding Separately Derived Alternating-Current Systems
  - III. Grounding Electrode System and Grounding Electrode Conductor
    - 250.50 Grounding Electrode System
    - 250.52 Grounding Electrodes
    - 250.66 Size of Alternating-Current Grounding Electrode Conductor
  - V. Bonding
    - 250.106 Lightning Protection Systems



Electrical Drawing Preparation
Grounding Plans – Lightning Protection

- NFPA 780 Standard for the Installation of Lightning Protection Systems
  - Chapter 4 Protection for Ordinary Structures
    - 4.2 Materials
    - 4.7.4 Rolling Sphere Method
    - 4.9.10 Number of Down Conductors
    - 4.13 Grounding Electrodes
    - 4.14 Common Grounding
    - 4.16.4 (Structural Metallic Systems) Grounding Electrodes
  - Annex L Lightning Risk Assessment





Electrical Drawing Preparation
Grounding Plans – Signal Reference

- IEEE 1100-2005 (Emerald Book)
  - Chapter 3 General needs guidelines
    - 3.3 Grounding considerations
  - Chapter 8 Recommended design/installation practices
    - 8.2 Equipment room wiring and grounding
    - 8.5 Grounding considerations
    - 8.6 Lightning/surge protection considerations
  - Chapter 9 Telecommunications, information technology, and distributed computing
    - 9.9 Grounding and bonding

[1] MIL-HDBK419A

[2] AFI 32-1065

[3] UFC 3-570-02A

[4] UFC 3-560-01