Eaton Electrical Engineering Services

Power Systems Engineering (PSE)

IEEE Nashville Chapter Meeting – October 2024

Gio Marchena | Engineering Manager, Southeast

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Agenda

1. Who is PSE?
2. Overview of PSE Study Process
3. Acquiring and Assuming Data
4. Practical Guide to 1584: Key Takeaways

Gio Marchena

Engineering Manager – Central & Eastern KY, Southern IN, TN, GA, AL & East MS

Currently located in Louisville, KY

Currently Reporting to Wally Tinsley – PSE Regional Engineering Manager, Southeast Region

Joined Eaton in June 2016

Value Proposition: Leveraging technical experiences for commercial success

Ask me questions about: EESS PSS Integration, sales development and my field experience.

I'd be willing to brainstorm on: Go to market strategy, resource leverage, and personal development

What Matters to Me – Family (Megan, Beau, & Brooks)

What Matters to Us – Sojourn East Community Church

Fun Fact – Played Baseball at Covenant College (2010-2012)

Alma Mater – University of Florida BS in Electrical Engineering (2015)

MBA – University of Arizona (2021)

Previous Experience
Career Timeline

2016 – 2018

Field Service Engineer

Nashville, TN

Responsible for testing, troubleshooting, commissioning and repair of power systems equipment.

2018 – 2019

Power Systems Controls Engineer

Nashville, TN

Responsible for design, testing, implementation and commissioning of switchgear controls

2019 – 2020

Power Systems Engineer

Nashville, TN

Responsible for execution of short circuit analysis, protective device coordination and arc flash studies.

2020 – 2023

Industrial Sales Engineer

Louisville, KY

Responsible for orders, sales, distributor and end user relationships.

2023 – Present

Engineering Manager

Louisville, KY

Responsible for commercial and operational execution/ development of the PSE business in KY, TN, GA and AL markets.

Complete Life Cycle Solutions with Eaton's Engineering Services Capabilities

Electrical Power Distribution Field Services
- 24/7 Emergency response
- Acceptance testing
- Startup
- Commissioning
- Maintenance
- Service contracts
- Multi-manufacture expertise

Electrical Systems Studies: Power Systems Engineering (PSE)
- Power Systems studies
- Harmonic studies
- Load flow analysis
- Arc flash studies
- CYME modules
- Microgrid feasibility and design studies
- Safety training

Switchgear Modernization
- Medium voltage and low voltage circuit breaker replacement
- Class 1 reconditioning
- Bus bracing & gear evaluation
- Arc flash mitigation

Foreseer Electrical Power Monitoring System
- Electrical power monitoring system
- Specialized solutions
- Reporting
- Training

Electrical Power Distribution Automation and Control Solutions
- Automatic power transfer upgrades & control systems
- Network design architecture
- PLCs & dashboards
- Multi-function protective relays-based monitoring & control systems

Cybersecurity Services
- Initial audit
- Comprehensive analysis
- Life-cycle management

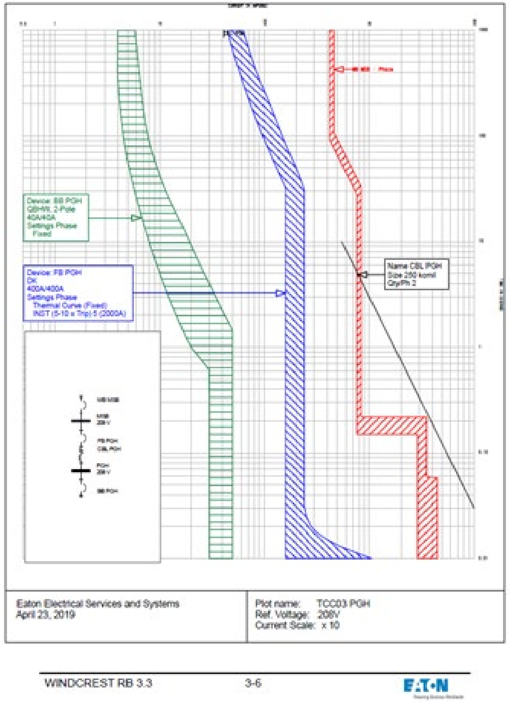
Turnkey Electrical Solutions
- Project management
- Substation design/build
- Multi-vendor equipment supply chain
- Engineering, Procurement & Construction (EPC)
- Crisis response
- Embedded resources

Grid Modernization Solutions
- Microgrid Systems & Distributed Energy Resources
- Synchronous Condenser Solutions
- Transmission & Distribution Solutions
- Modular & Mobile Solutions
- Hydroelectric Solutions

5

Who is EESD – Power Systems Engineering?

1. We ANALYZE, MONITOR and MAKE RECOMMENDTIONS related to **Power Systems**
   1. Specifically, in regard to people safety, equipment protection and system health
2. The two major components of our business:
   1. **Doing**
   2. **Teaching**



Doing…

We provide professional engineering analysis and consulting for…

Safety and Reliability Analysis

- Short Circuit, Coordination, & Arc Flash
- Load Flow & Power Factor Correction
- Motor Starting Analysis
- Bus Bracing Analysis
- Disturbance Monitoring
- Harmonic Analysis
- Switching Transient Analysis
- Power Quality & Grounding Surveys
- Field Collection of System Data
- Connection of Power Quality Meters

Facilities:

Public and private sectors

- Institutions & educational facilities
- Healthcare & Lodging
- Commercial Office
- Retail Facilities
- Government and Public facilities
- Industrial facilities
- Airport terminals
- Data Centers

We provide Training focused on the Safety of equipment and personnel

- Electrical Safety In The Workplace: NFPA-70E
  - Interacting with Electrical Equipment
  - Arc Flash and Electric Shock
  - Approach Boundaries
  - De-Energization & Lockout / Tagout
  - Grounding
  - Personal Protective Equipment (PPE)
  - OSHA Standards and Regulations
- Local Support for Lunch-and-Learns
  - Large and experienced local engineering team that can support customer visits

Public and private sectors

Audiences:

Operators

Maintenance Personnel

Technicians

Engineers

Electrical Contractors

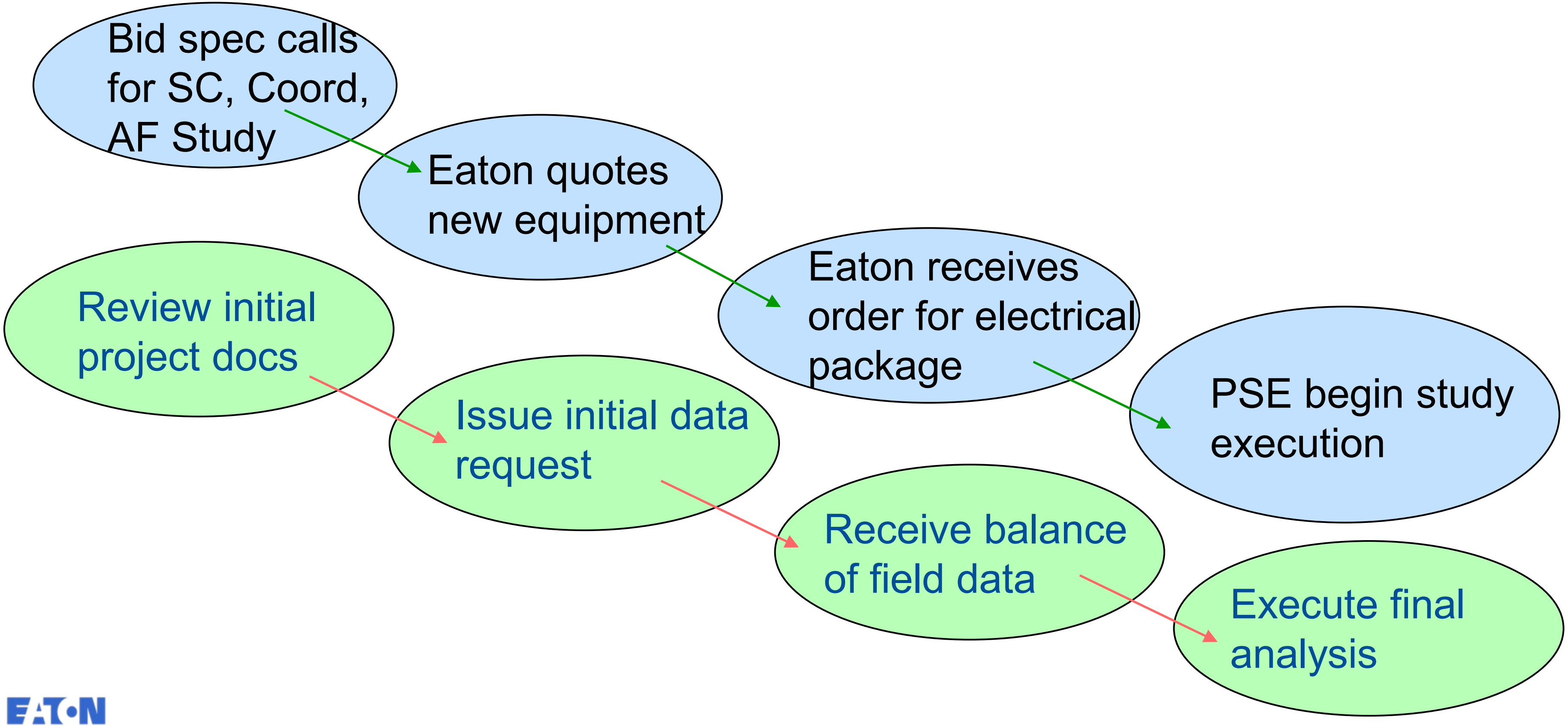
Safety Personnel

PDH's and CEU's

Decision Makers ($)

Teaching…

Where do we fit in the project life cycle



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PSE Studies

Typical studies include data collection and (3) evaluations:

1. Data Collection if PSE quoted(optional) or Bidman quoted(if appropriate)
2. Short Circuit & Device Evaluation Study
3. Protective Device Coordination Study & Selective Coordination
4. ***Arc Flash Analysis***

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Detail Bill of Material Page 1 of 13

Project Name:	WINDCREST RB 3.3	**Negotiation No:**	DN910126X8K2
General Order No:	LDN0020735	**Alternate No:**	R000

Item No.	Qty	Product	Description
037	1	EESS Services	EESS Short Circuit and Coordination Studies: Arc Flash Hazard Analysis, Arc Flash Labels - Standard

See Approval Drawings for Clarifications and Exceptions
Patrick Levy

Designation Coordination Study

Qty	List of Materials
1	ESS Study-BidManager
1	2 Weeks Lead Time for Data Request Submittal
1	3-4 Weeks Lead Time for Study Completion
1	Quoted by Bid Manager
1	Arc Flash study
1	Arc Flash Labels - Standard

PSE Studies: Gathering System Data

We always start with Data:

1. Data Collection: *PSEs onsite to gather information required to develop a system one line*
   - Always requires site personnel to assist
   - Always requires the removal covers of electrical equipment
   - **WE CANNOT START ON A STUDY UNLESS WE HAVE *INTIAL* DATA**
   - We include it as optional but STRONGLY encourage:
     - For accuracy of data
     - Study cost will be higher if we don't perform DC due to time associated with revising the data received
     - Customer/contractor can perform DC

PSE Studies

What if we(PSE) is not commissioned to capture field data:

DATA REQUEST

Eaton Electrical Services & Systems
4620a Proximity Dr.
Louisville, KY 40213

November 5, 2024

From: Contractor Name
EESS Power Systems Generic Data Request
Ph: Phone Number
Email: Email

Project: Project Name

General Study Data Requirements:

Please provide the following information to your local sales representative for distribution to Eaton PSE group. Contact us with any questions regarding this data request and a member of our local Alabama Power Systems Engineering team will assist you.

1. **General Project Information:**
   - ☐ Site Contact Name, Phone, and Email
   - ☐ Project Address / Location
   - ☐ Project Schedule / Expected Equipment start-up date.
   - ☐ Complete Electrical Drawing Set in pdf format
   - ☐ Confirm System Selective Coordination distribution / Specific Study Requirements
2. **Utility Information: *Provide Utility contact name, phone number, and email address***
   - ☐ Service Transformer Nameplate and Fault Data: Send attached sheet to utility contact
3. **Cable Information: New and Existing cables/feeders to equipment included in study**
   - ☐ Cable Size, Number per Phase, Cable Length (and/or detailed conduit schedule)
   - ☐ Copper vs. Aluminum, Conduit (Magnetic vs. Non-Magnetic)
   - ☐ Please add cable information and rows as needed to house that information below:

Cable Origin	Cable Termination	CU or AL	Length(ft)	Size	# of Cables per Phase	Magnetic or Non-Magnetic Duct Material	Insulation Class

PSE Studies

What if we(PSE) is not commissioned to capture field data:

3. Cable Information: New and Existing cables/feeders to equipment included in study

- Cable Size, Number per Phase, Cable Length (and/or detailed conduit schedule)
- Copper vs. Aluminum, Conduit (Magnetic vs. Non-Magnetic)
- Please add cable information and rows as needed to house that information below:

Cable Origin	Cable Termination	CU or AL	Length(ft)	Size	# of Cables per Phase	Magnetic or Non-Magnetic Duct Material	Insulation Class

4. **Motor Information:** Provide Motor feeder / panel schedule drawings

- For motors <50hp, please indicate lump sum motor contribution with total horsepower and total number of motors.
- For motors >50hp, please provide nameplate information including the following:
  - Hp, Voltage Rating, Rpm, Service factor, FLA, Locked Rotor Code

5. Circuit Breaker Information:

- Manufacturer, Type / Catalog # (Note thermal magnetic vs. electronic)
- Short Circuit kAIC Rating,
- Frame Rating, Plug Rating, Sensor Rating
- Trip Unit Type & Functions Available (LS, LSI, LSIG, etc.)
- Phase and Ground Overcurrent Settings (if existing)

PSE Studies

What if we(PSE) is not commissioned to capture field data:

Eaton Electrical Services & Systems
4620a Proximity Dr.
Louisville, KY 40213

DATA REQUEST

6. **Fuse Information: *Provide cutsheets / shop drawing submittals / photos of existing***
   - ☐ Manufacturer
   - ☐ Type / Catalog #
   - ☐ Size
   - ☐ Speed

7. **Relay Information: *Provide cutsheets / shop drawing submittals / photos of existing***
   - ☐ Manufacturer
   - ☐ Type, Style Numbers
   - ☐ CT Ratios
   - ☐ Settings Ranges
   - ☐ Phase and Ground Overcurrent Settings (if existing)

8. **Generator Information:** Generator Manufacturer's Submittal Information including:
   - ☐ Size (kVA or kW), Voltage
   - ☐ Circuit Breaker Information including manufacturer, type, frame, trip unit and functions.
   - ☐ Manufacturer Decrement Curve and Withstand Curve
   - ☐ Alternator data sheet including generator reactances & time constants
     - ☐ Please note the alternator data sheet is typically found in the manufacturer's submittal package and cannot be obtained in the field. This information should be requested from the manufacturer.

9. **ATS Information: *Provide Bill of Material / shop drawing submittals / photos of existing***
   - ☐ Manufacturer, Type
   - ☐ Voltage Rating
   - ☐ Continuous Current Rating
   - ☐ Short Circuit Withstand Rating (kAIC)

PSE Studies: Gathering System Data

What if we(PSE) cannot obtain the data from the field: We use and clearly define assumptions

1. What we always need: One-line + Bill of material
2. *Assumptions are based on what analysis we perform:*
   1. *Short Circuit Analysis:*
      1. *Always Need: One-line + Bill of material, Utility XFMR Size OR Utility Fault Contribution*
      2. Can live without: Cable Info**
   2. *Standard Coordination:*
      1. *Always Need: One-line + Bill of material*
      2. Can live without: Utility XFMR Size, Utility Fault Contribution
   3. *Arc Flash:*
      1. *Always Need: One-line + Bill of material, Utility XFMR Size, Cable Length, Generator Sizes + Submittal*
      2. *Can live without: Utility Fault Current, Utility XFMR Actual Z%*

PSE Studies: Gathering System Data

What if we(PSE) cannot obtain the data from the field: We use and clearly define assumptions

1. *Other Assumption Guidelines:*
   1. *Cable Data:*
      1. *When specific cable data missing we use the “NEC Table 310.16” entry in SKM, with non-magnetic conduit/raceway*
      2. *LV Cable Length: 19’*
      3. *MV Cable Length: 49’*
   2. *When utility transformer info is missing but have Service Entrance amps:*
      1. ***Always Need: S=√3 V_(L-L) I_L = XFMR KVA***
      2. ***Ex. 1600A Main Swithboard = 1329 kVA or next highest standard size = 1500kVA***
      3. ***Typical XFMR Impedance Size:***

Table 1—Impedance Data for Three-Phase Transformers With Primaries of Up to 15 000 V and Secondaries of 600 V or Less

kVA 3Θ	Suggested *X/R* Ratio for Calculation	Normal Range of Percent Impedance (see notes)
112.5	3.0	1.6 – 2 Min – 6.2
150.0	3.5	1.5 – 2 Min – 6.4
225.0	4.0	2.0 – 2 Min – 6.6
300.0	4.5	2.0 – 4.5 Min – 6.0
500.0	5.0	2.1 – 4.5 Min – 6.1
750.0	6.0	3.2 – 5.75 – 6.75 – 6.8
1000.0	7.0	3.2 – 5.75 – 6.75 – 8.0
1500.0	7.0	3.5 – 5.75 – 6.75 – 6.8
2000.0	8.0	3.5 – 5.75 – 6.75 – 6.8
2500.0	9.0	3.5 – 5.75 – 6.75 – 6.8

NOTES:

1 — Underlined values are from ANSI C57.12.10-1977 [1], ANSI C57.12.22-1980 [2], and NEMA 210-1976 [10].

2 — Network transformers (with three-position swithches) have 5.0%Z for 300–1000 kVA, 7.0% Z for 1500–2500 kVA, (with two-position switches) 4.0% Z for 500–750 kVA. See ANSI C57.12-40-1982 [3].

3 — Three-phase banks with three single-phase transformers may have values as low as 1.2%.

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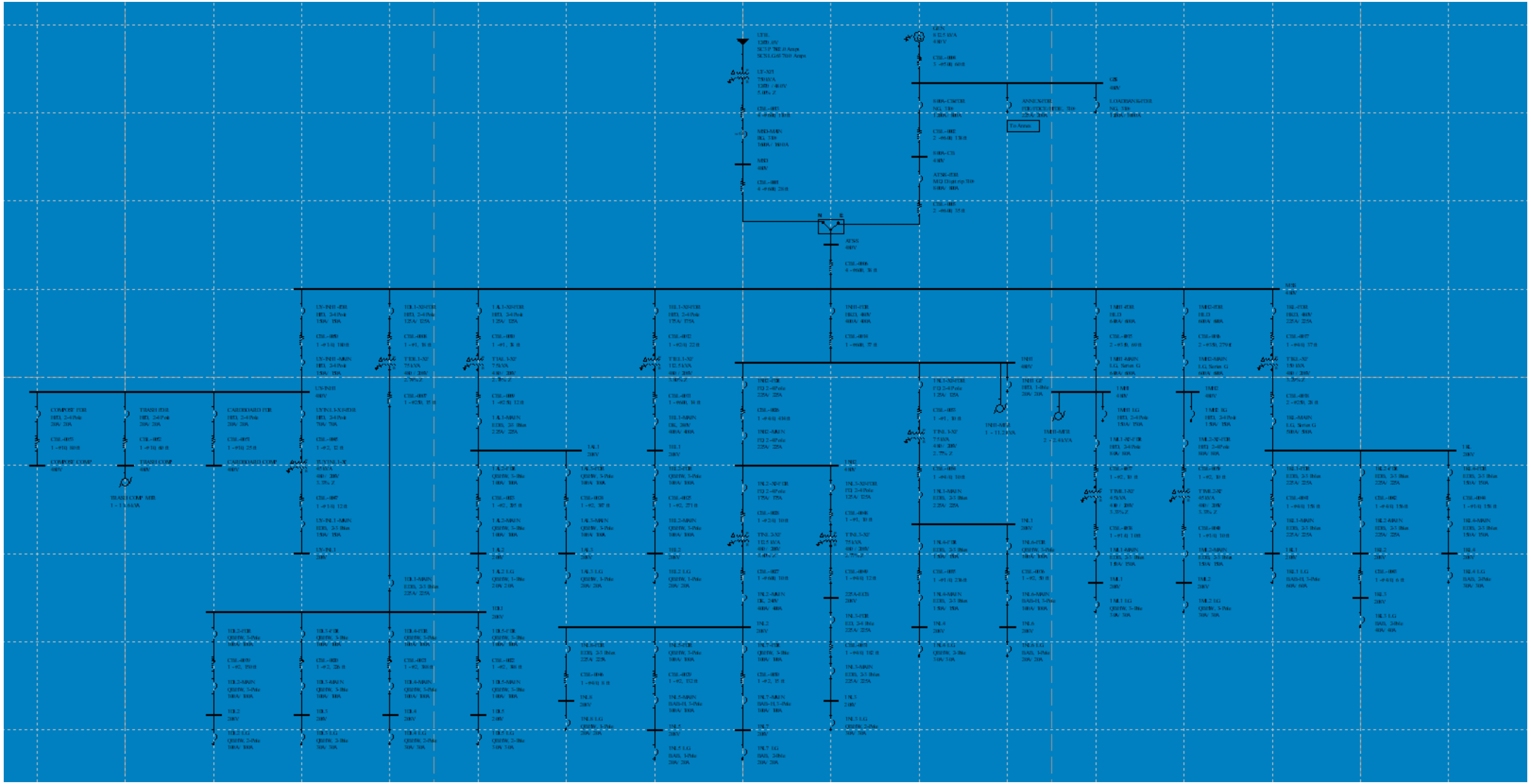
Example SKM Model



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PSE Studies

Typical studies include 4 evaluations:

2. Short Circuit & Device Evaluation Study

Ensures equipment fault current ratings (kA) are adequate to safely clear faults as required → NEC

Table 2.1 – Low-Voltage Equipment Evaluation

Bus I.D.	Manufacturer	Status	Type	Bus Voltage (V)	Calc Isc (kA)	Equip Isc (kA)	Rating %
ATS EM	Cummins	Passed	LV ATS	208	29.73	30.00	99.10
ATS OS	Cummins	Passed	LV ATS	208	29.59	30.00	98.63
DS ATS EM	Eaton	Passed	Safety Switch	208	1.97	10.00	19.67
DS ATS OS	Eaton	Passed	Safety Switch	208	1.97	10.00	19.67
DS ELEV 1	Eaton	Passed	LV Control	208	1.46	10.00	14.64

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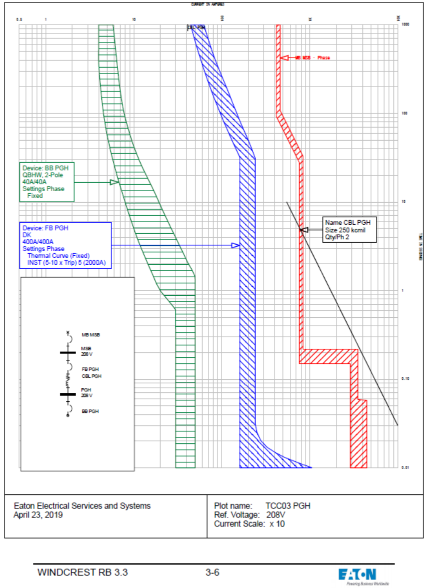
PSE Studies

Typical studies include 4 evaluations:

3. Protective Device Coordination Study

Optimizes adjustable trip settings for system reliability (selectivity) and ensures equipment (e.g. cables and transformers) is safely protected → IEEE & NEC



4.0 RECOMMENDED PROTECTIVE DEVICE SETTINGS

The following table shows a comprehensive summary of the recommended settings for the adjustable protective devices. The devices are grouped by system bus name/location. Refer to Section 11.0 for the system one-line diagram.

Table 4.1 - Recommended Low-Voltage Protective Device Settings

Location	Name / Type	Description	Frame / Sensor / Plug	Recommended Settings	TCC
GEN	CB GENERATOR	SQUARE D	1200A	Phase	12
	Static Trip	Powerpact P-Frame, 6.0A/P/H	1200A	LTPU/LTD (A 0.4-1.0 x S) 1 (1200A); 1	
			1200A	STPU (1.5-10 x LTPU) 4 (4800A)	
				STD (0-0.4) 0.4 (I^s T Off)	
				INST (2-15 x S) 15 (18000A)	
				Ground	13
				GFPU (0.2-1.0 x S) A (240A)	
				GFD (0-0.4) 0.4 (I^s T Off)	
				ARMS	14
				ON Mode ON (1200A)	
MSB	MB MSB	EATON	4000A	Phase	01
	Static Trip	Magnum SB, DT 520	4000A	Ir, (0.4-1.0 x P) 1 (4000A)	
			4000A	LTD, (2-24 Sec.) 4	
				STPU, (2-10 x Ir) 2 (8000A)	
				STD, (0.1-0.5 Sec.) 0.2 (I^s T Off)	
				INST, (2-14 x P) 8 (32000A)	
				ARMS	02
				MM switch, (R1-R5 x P) R4 (16000A)	

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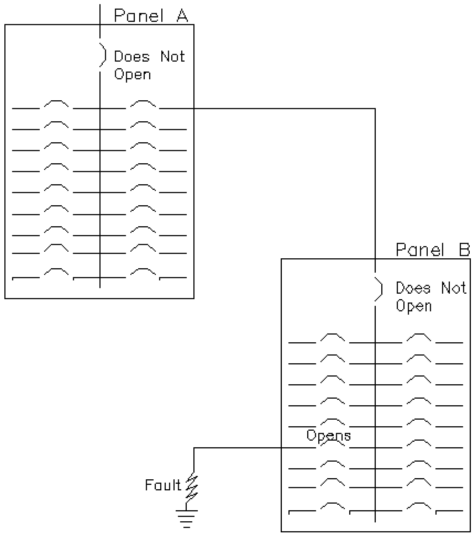
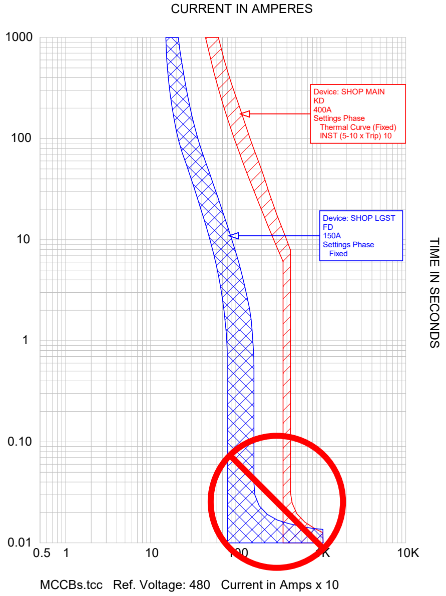
PSE Studies

Typical studies include 4 evaluations:

4. Selective Coordination Evaluation





- New distribution system designs
  - Look for systems with generators & automatic transfer switches
  - Drawings often state if an ATS is life-safety, legally required, or emergency.
  - Look for drawing notes or specs that call-out the requirement to meet "selective" coordination and/or NEC 700.27 or 701.18.
  - Review the specs to see if NEC 700.27 or 701.18 is called out in any sections.

PSE Construction Studies

Typical studies include 4 evaluations:

5. Arc Flash Analysis

Quantifies available arc flash incident energy (cal/cm^2) and approach boundaries enabling a worker to select appropriate PPE for safe work → OSHA & NFPA-70E

Table 5.1 – Arc Flash Incident Energy Analysis Summary Table

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary (ft & in)	Working Distance (ft & in)	Incident Energy (cal/cm^2)
ATS EM	FB ATS EM (E)	0.208	2.27	1.96	1.26	2	0.0000	Yes	PNL	25	4' 6"	1' 6"	7.2
ATS OS	FB DS ATS OS	0.208	1.96	1.96	1.26	2	0.0000	Yes	PNL	25	4' 5"	1' 6"	7.1
DS ATS EM	FB ATS EM (E)	0.208	2.28	1.97	1.26	2	0.0000	Yes	PNL	25	4' 6"	1' 6"	7.2
DS ATS OS	FB DS ATS OS	0.208	1.97	1.97	1.26	2	0.0000	Yes	PNL	25	4' 5"	1' 6"	7.1
DS ELEV 1	FB DS ELEV 1	0.208	1.00	0.88	0.63	1.848	0.0000	Yes	PNL	25	2' 8"	1' 6"	3.1
DS ELEVE 2	FB DS ELEV 2	0.208	1.03	0.87	0.63	1.848	0.0000	Yes	PNL	25	2' 8"	1' 6"	3.1
EM	FB ATS EM (E)	0.208	2.25	1.94	1.25	2	0.0000	Yes	PNL	25	4' 5"	1' 6"	7.1
GDP	CB GENERATOR	0.208	13.24	12.95	2.54	2	0.0000	Yes	PNL	25	7' 5"	1' 6"	16.6

A PRACTICAL APPLICATION OF IEEE STD 1584-2018

A PRACTICAL APPLICATION OF IEEE STD 1584-2018

Paper No. PCIC-

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Abstract – The IEEE Std. 1584-2018 Guide for Performing Arc-Flash Hazard Calculations presents new challenges in data gathering and equipment modeling due to the removal of the 125 kVA exception and the addition of the ability to model electrode configurations, enclosure dimensions, and bus gaps. Engineers must now understand equipment construction and choose whether to field measure equipment and use actual data, or use the typical values presented in IEEE-Std.1584-2018. This paper will discuss how incident energy (IE) and arc-flash boundary

II. OVERVIEW OF CHANGES

A. Electrode Configurations

Electrode configurations are a new addition to IEEE Std. 1584-2018. Previously, there was a choice between whether the arc occurred within a box, or in open air. Now, there are five configurations to choose from: 3 for an arc within a box enclosure, and 2 for an arc in open air.

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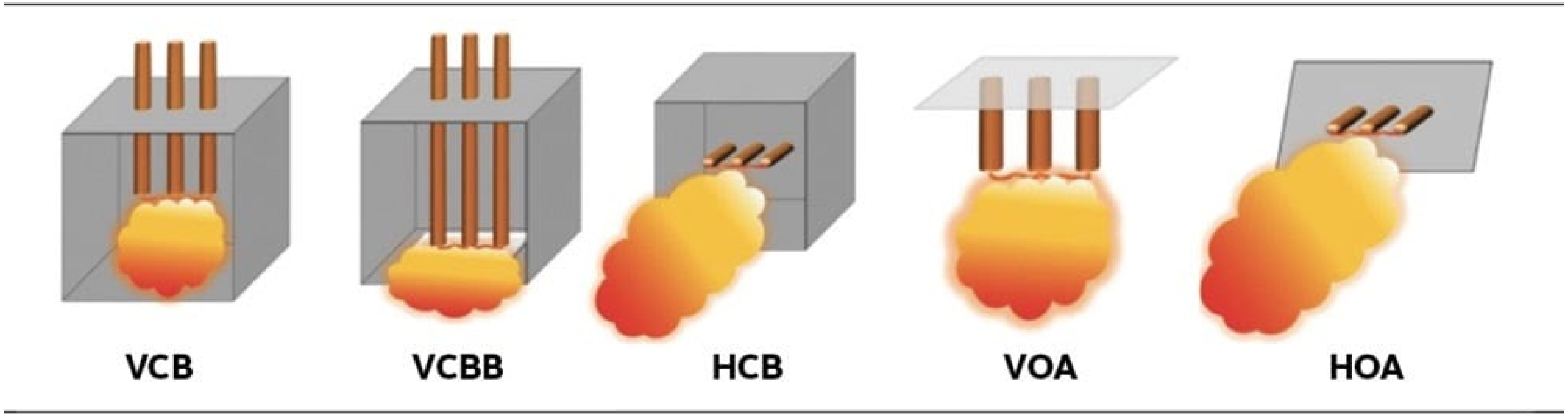
Major Changes: Distinction in Electrode Configuration



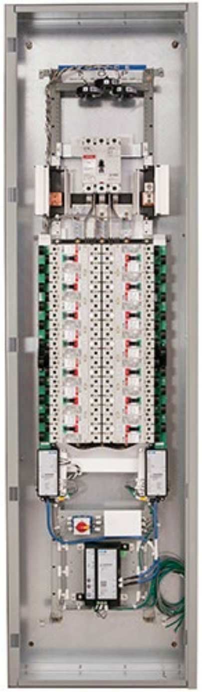
arc flash direction in the various electrode/bus configurations

Typical Electrode Configuration: LV Switchgear

- Proposed Electrode Configuration:
  - Low Voltage (LV) Switchgear: Typical LV switchgear installations may have all three enclosed configurations present. VCB and VCBB can be present when the circuit breaker is in a cubicle (Refer to Fig. 6). HCB may be present when a circuit breaker is removed from a cubicle and the circuit breaker stabs are exposed and pointed towards the worker. (Refer to Fig. 7). When the rear of switchgear is exposed, VCB, VCBB or HCB may be present depending on the bus insulation and orientation of conductors with respect to the worker (Refer to Fig. 8).

Typical Electrode Configuration: LV Panelboard

- Proposed Electrode Configuration:
  - Typical low voltage panelboards and loadcenters may have VCB or VCBB present. VCB may be present when an arc is initiated and travels to the bottom of the main vertical bus. (Refer to Fig. 9). VCBB may be present if a molded case circuit breaker acts as a barrier at the vertical bus. It is unlikely that an HCB fault will occur within a panelboard because there is no significant horizontally oriented bus. There may be small pieces of horizontal bus that appear to point towards the opening (such as bolt heads or lug terminations), but they are likely not long enough to redirect the arc plasma horizontally towards the enclosure opening.



Typical Electrode Configuration: LV Switchboard

- Proposed Electrode Configuration:
  - Typical low voltage switchboards have feeder sections that are similar to panelboards and may have VCB or VCBB present depending on whether a circuit breaker acts as an insulating barrier. It is unlikely that an HCB fault will occur within a switchboard feeder section because there is no significant horizontally oriented bus, similar to a panelboard. At a switchboard main incoming/utility compartment, there may be horizontal runs of bus that appear to be HCB, but the bus spacing is typically greater than the upper limit of the gap range of model. Therefore, for a typical switchboard, HCB may be ignored. (Refer to Fig. 10).

Typical Electrode Configuration: LV Disconnect

- Proposed Electrode Configuration:
  - Typical low voltage disconnect switches (fused or non-fused) may have VCB or VCBB present. VCB may be present when an arc is initiated at the vertical bus within the switch. VCBB may be present if a fuse or other device acts as an insulating barrier at the vertical bus. Even though small conductors such as fuse clips may appear to be pointed towards the opening, in the authors opinion, fuse clips are not likely to be long enough to redirect the arc plasma towards the worker. (Refer to Fig. 11).

Typical Electrode Configuration: LV Motor Control Centers

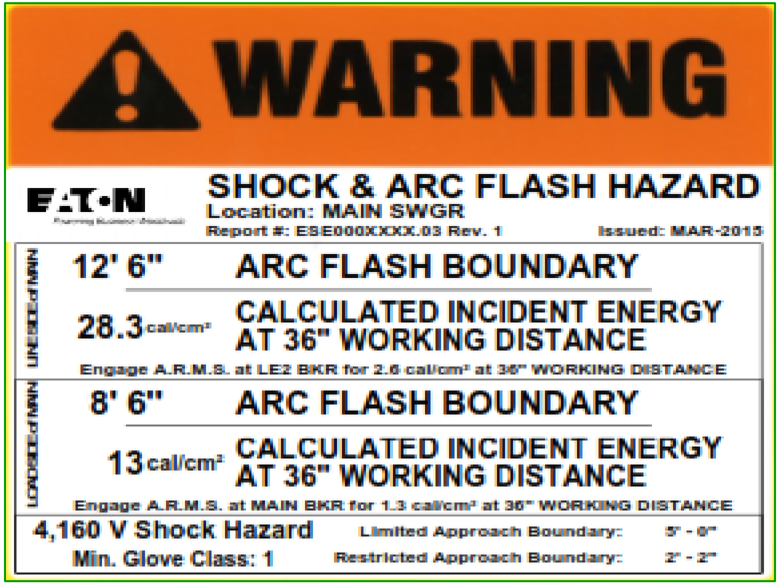
- Proposed Electrode Configuration:
  - Typical motor control centers buckets have an overcurrent protective device that may have VCB or VCBB present depending on where the arc is initiated relative to an insulating barrier. (Refer to Fig. 12). HCB is not likely to be present within a motor control center bucket because there is typically no horizontal conductor that would be pointed at the worker. Opening the rear compartments of a motor control center is likely to expose vertical runs of bus that are not likely to point towards the worker in an HCB manner.

Typical Electrode Configuration: MV Switchgear

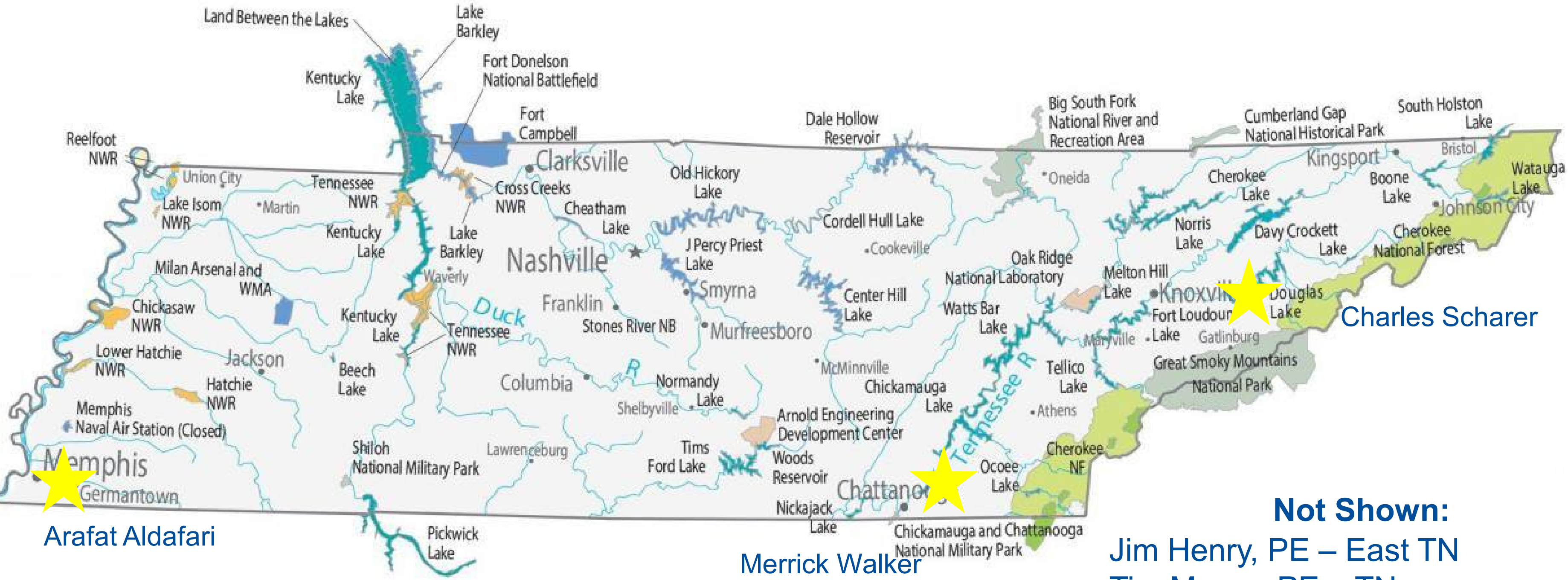
- Proposed Electrode Configuration:
  - In addition to VCB and VCBB conductors, medium voltage switchgear, MCCs and switches are more likely to have horizontal bus runs that will behave like an HCB fault.

Other Practical Considerations

- **Situation**: System w/ mutiple considerations(mutiple utility sources, utility + gen, multiple utility sources + gen, etc.)
  - *Response*: Run mutiple scenarios → print worst case IE on label
- **Situation**: System with ARMS(Arc Flash Reduction Maintenance System)
  - *Response*: Run mutiple scenarios → print multiple labels for different modes of operation
- **Situation**: Switchboard with main breaker(UL 891 Construction)
  - *Response*: Label with separate lineside AND loadside IE calculations
- **Situation**: MCC with multiple(<50 HP)
  - *Response*: Modeled as a lumped load(represented at large motor)



PSE Coverage for TN



Charles Scharer

Arafat Aldafari

Merrick Walker

Not Shown:

Jim Henry, PE – East TN
Tim Moore, PE – TN
Jorge Posada, PE – KY
Richard Moore, PE – Bowling Green, KY

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Thank you!

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