NFPA 70E Electrical Safety with Lorn MacIlravie

2025

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Calculations | Contact

ELECTRICAL CALCULATIONS FOR ELECTRICIANS

NEC Calculations

Box Fill - NEC 314.16

Conductor Sizing

Motor Conductor Sizing

Conduit Sizing

Locked Rotor Current, "LRC"

NEC Table 450.3(A) Calculator

NEC Table 450.3(B) Calculator

Voltage Drop

"Easy" Voltage Drop Calculator

Chapter 9, Table 8 Voltage Drop Calculator

Chapter 9, Table 9 Voltage Drop Calculator

Circular Mils from Voltage Drop

Basic Electrical

Ohm's Law

Power Equation

Amperes from Horse Power

Amperes from KVA

Amperes from KW

Horsepower

Kilowatts, "KW"

Kilovolt-Amperes, "KVA"

Other

Rod Pump Flow

Linear Signal Scaling

Positive Displacement Pump Flow

Power Factor Correction

3 Phase Line Reactor Impedance

Transformer Fault Current

Electric Motors

Single Phase Motor Charts

Three Phase Motor Charts

Motor Fuses

Motor Overloads

Miscellaneous

Dipoles

Downloads

Electrical Drawings

Links

Lorn MacIlravie Art

Just like Mom made....

- Emergencies and Exits
- Sign in sheet
- Cell Phone and other Distractions
- Bathrooms
- Schedule and Breaks
- Lunch Plans
- Final Test
- Questions before we start?
- Why are you taking this class?

Electrical Shock

- Electrical shock can stop your heart.
- Shock can damage your brain and nervous system.
- Current can cook you.
- Shock is far more common than the next hazard.

Electrical Shock

- NFPA Article
- BLS - Injuries, Illnesses, and Fatalities
- 50 Volt Magic Number? 110.4(C)
- Touch Potential
- Step Potential

mA?

- What's a mA?
  - 1A / 1000 = 0.001 A, or 1 mA
- How much electrical current does it take to kill a person?
  - ...that depends...

mAs can Kill

- Factors:
  - Age
  - Health
  - Skin
  - Environment

mAs can Kill

mA	Effect
1	You might feel it
5	GFCI Trip
10 -25	Can't let go
75 - 100	Ventricular Fibrillation
180	Tissue Damage
200	Burning
>400	Heart Stops

What is a Arc Flash and a Arc Blast

- “A source of possible injury or damage to health associated with the release of energy caused by an electric arc.” Definitions
- See Informational note!
- Video

Arc Flash, Arc Blast, Thermal Burns

- “Fear is the path to the dark side. Fear leads to anger. Anger leads to hate. Hate leads to suffering.”
  - Yoda

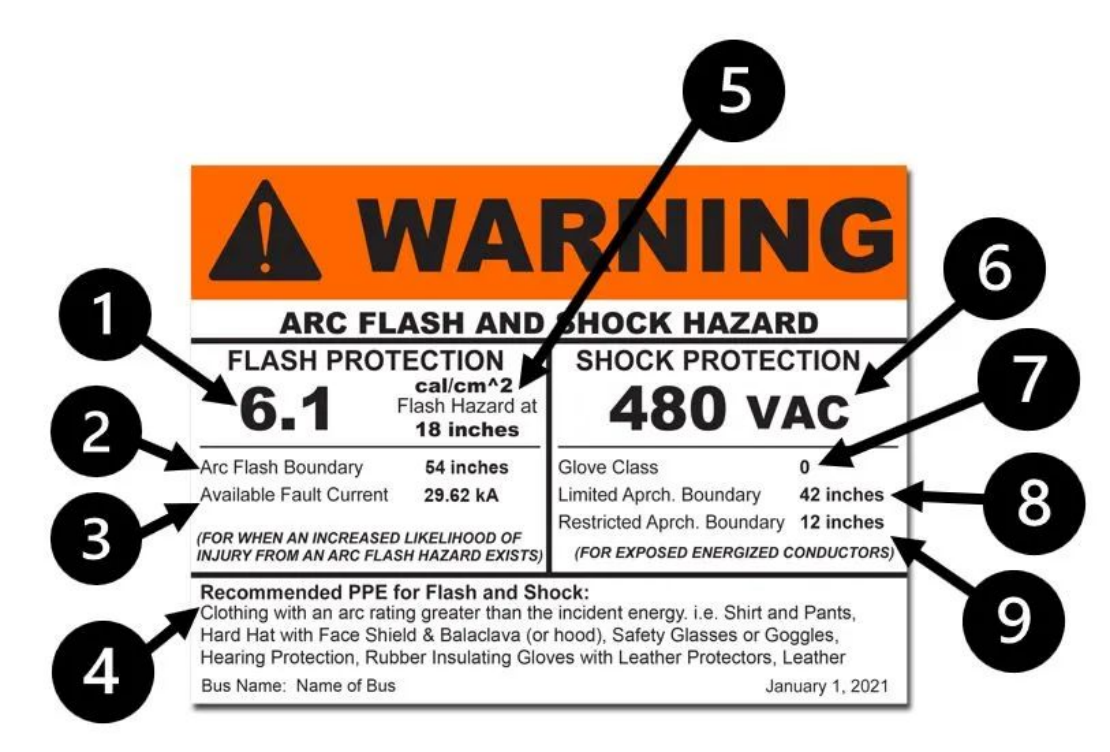
Arc Flash, Arc Blast, Thermal Burns

- “Heat is the path to the dark side. Heat leads to Arc Flash. Arc Flash leads to Arc Blast. Arc Blast leads to suffering and Thermal Burns.”
  - Stolen and reworked by Lorn

Arc Flash, Arc Blast, Thermal Burns

- cals/cm^2
  - 1.2 cals/cm^2 is the amount of thermal energy to causes 2nd degree burn.
- Incident Energy (IE), cal/cm^2
- Working Distance

Arc Flash, Arc Blast, Thermal Burns



NFPA

- National Fire Protection Association
- Writes and maintains standards
- Nationally, in Internationally, Recognized

OSHA

- Occupational and Health Administration
- 29 CFR Parts 1910 and 1926?
- https://www.osha.gov/
- National safety organization
- Uses standards, like the NFPA 70E, for promoting and enforcing safety law.

NFPA 70

- NFPA 70, 90.2 (A)
  - "...The purpose of this code is the practical safeguarding of person and property front he hazards arising from the use of electricity..."
- Minimum standard for electrical work
- Enforceable by the AHJ

AHJ

- Authority Having Jurisdiction
- Legal term used by OSHA, NFPA documents, etc.
- Who is the AHJ where you are working?
- Are there multiple AHJs?

NFPA 70E

- NFPA 70E, 90.1
  - “The purpose of this standard is to provide a practical safe working area for employees relative to the hazards arising from the use of electricity”
- Minimum standard for electrical safety
- Handbook

NFPA 70E Organization

- Chapter 1: General Electrical Safety
- Chapter 2: Electrical Maintenance Safety
- Chapter 3: Special Mods to Chapter 1
- Annexes: Informational Info... NOT mandatory.
- We are focusing on Chapter 1 today.

Turn the power off!

In a nutshell, if you only get one thing from this presentation, turning the power off will go a long way to keep you safe.

NFPA 70E Article 90.4

- Mandatory Rules, Permissive Rules, and Explanatory Material
- “...shall or shall not...
- “...shall be permitted or shall not be required...”
- Explanatory Material = Informational Notes

NFPA 70E Article 100

- Definitions
- Look up the following:
  - Arc Flash Hazard
  - Shock Hazard
  - Electrically Safe Work Condition

Employer Responsibilities 1

105.3 (A)(1) “Establish, document, and implement the safety-related work practices and procedures required by this standard."

Employer Responsibilities 2

105.3 (A)(2) “Provide employees with training in the employer’s safety-related work practices and procedures.”

Employee Responsibilities

105.3 (B) “The employee shall comply with the safety-related work practices and procedures provided by the employer.”

Turn the power off!

110.1 Priority.

“Hazard elimination shall be the first priority in the implementation of safety-related work practices.”

Energized Work or Hot Work?

- **Energized**: “Electrically connected to, or is, a source of voltage” NFPA 70E, Article 100
- **Hot Work**: “work involving electric or gas welding, cutting, brazing or similar flame or spark-producing operations.”

Energized Work

- Energized work is working on, moving, or touching energized conductors.
- Energized work is NOT the norm.
- Energized work SHOULD be avoided at all cost.

Energized Work, 110.4 Exception

- (A) Additional Hazards or Increased Risk
- (B) Infeasibility
- (C) Equipment Operating Less Than 50 Volts

Energized Work, 110.4 Exception

Energized work is NOT testing or troubleshooting.

Energized Work

- Energized work requires an energized work permit.
- Let’s look at a copy of your energized work permit and the procedure to fill it out.

Testing

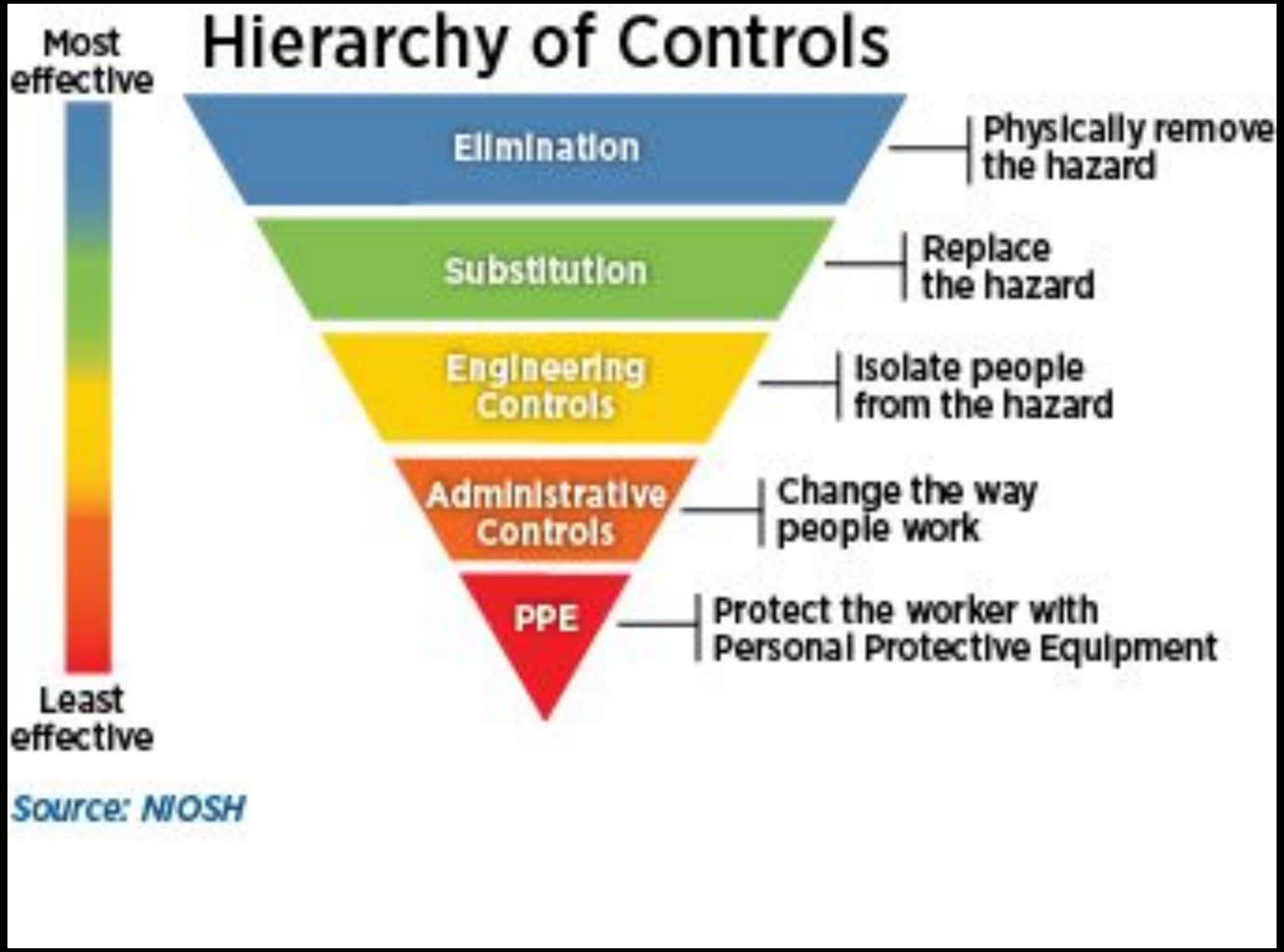
- Testing and troubleshooting are NOT energized work, but it has a LOT of the same hazards.
- Limits of “Testing”?
  - Voltage
  - Current

Turn the power off!

Conditions apply to ALL energized work, testing, and troubleshooting. Choose a de-energized state to do your work.

What is your Electrical Safety Program?

Please show me your JSA, JRA, or your company's risk assessment procedure.


Hierarchy of Controls
Most effective
Least effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment
Source: NIOSH

Training

- Prior Experience
- Traditional on Online Schooling
- OJT, On the Job Training
- Safety Training
- **Qualified Person**
- Employer Responsibilities

Qualified Person

"One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risks."

- Definition from NFPA 70E Article 100

Who is CPR and AED Trained?

Host Employers. 110.7 (A)

- Host employers need to tell you about the hazards at the job site before you begin working. They also have to communicate their own specific rules.
- Ask your host employers for clear documentation.

Contract Employers, 110.7 (B)

- Contractor need to inform the host employers of any unique hazards of their work.
- Communicate. Document everything.
- “If it isn’t written down, it didn’t happen.”
  - By Peter Hampton

What is your LOTO, Lock Out Tag Out Program?

How do you coordinate your program with those of your host employers?

Safety Glasses

- Z87+

Gloves 130.7(C)(7)

- What’s you company policy for work gloves and hand protection?
- Insulating Gloves and Arc Flash protection
- Issuing and Testing, 6 mo Rule

Gloves 130.7(C)(7)

- Color
- Marking and Rating
- Cuff Length
- Inspection Demo
- Best Practices for use

ELECTRICAL INSULATED GLOVES

ASTM Labeling Chart

Class Colour	Proof Test Voltage AC/DC	Max Use Voltage AC/DC	Insulating Rubber Glove Label Colour
00 Beige	2,500 / 10,00	500 / 750	
0 Red	5,000 / 20,00	1,000 / 1,500	
1 White	10,000 / 40,000	7,500 / 11,250	
2 Yellow	20,000 / 50,000	17,000 / 25,500	
3 Green	30,000 / 60,000	26,500 / 39,750	
4 Orange	40,000 / 70,000	36,000 / 54,000	

ARC Resistant Clothing

Cat 1-4

Layering

Natural Fibers

Jewelry

Hearing Protection

ARC Resistant Clothing

Face Shields

Clothing requirements and Labels

Fit

Contamination

Footwear

- Voltage Rated
- Static Rated
- Arc Rated...
- Steel Toe or Composite?
- Your policies?

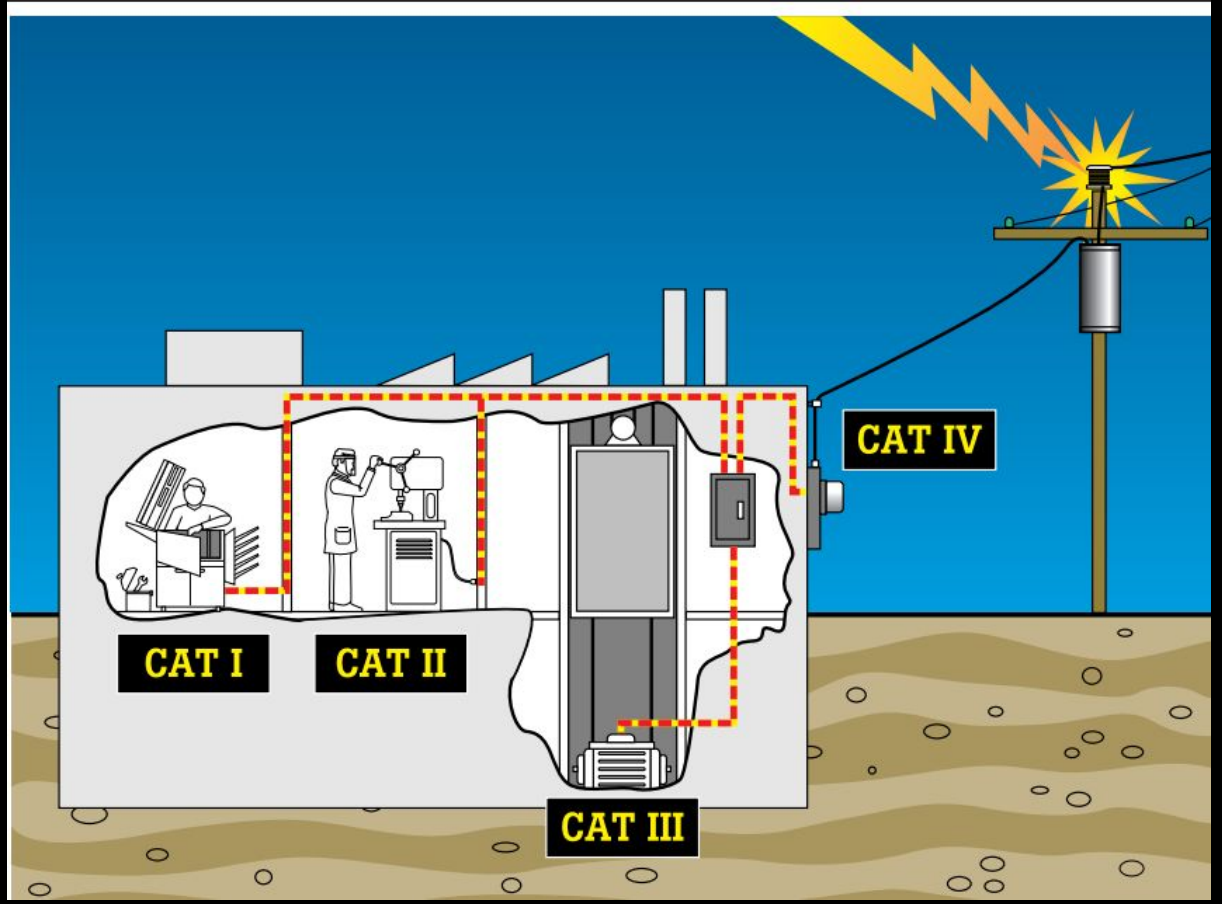
Insulated Tools

- Required when “working” on or near energized equipment.
- Inspect before use
- Two color system

Meters

- CAT, or Category System
- BYOM, Bring Your Own Meter Discussion
- How to use a multimeter like a pro! The Ultimate guide
- Practical Use of Your Electrical Meters

Understanding categories: Location, location, location



GFCIs

- How do GFCIs work?
- Use in the field
- Use at home and the office

The Big Job

- Planning
  - Who does this at your company?
- Briefing
  - Do you have a tailgate meeting policy?
- Procedures
  - Do you have specific procedures for work?

The Big Job

- Write the plan on paper and communicate to everyone.
- Capture changes the scope of work, then communicate those changes.
- Finish, close out, then review the work.

Human Performance

- Informative Annex Q
- People are fallible...
- Concepts:
  - Pre-job Meeting
  - Review Jobsite
  - Use a procedure

Human Performance

- Concepts Continued:
  - Flagging and Blocking
  - Reader - Actor (3 Way Communication)
  - Stop Work Authority
  - Post Job Review

Creating an Electrically Safe Work Condition, 110.3

- Procedure, 120.1
- 50 Volt Rule, and its limitations
- Approach Boundaries define areas where there shock and arc flash hazards
- Worksheet

Maintenance Switches

-

Blankets and Shields

-

Arc Flash Labels

Nom. Voltage

Arc Flash Boundary

NFPA 70E 130.5(H)

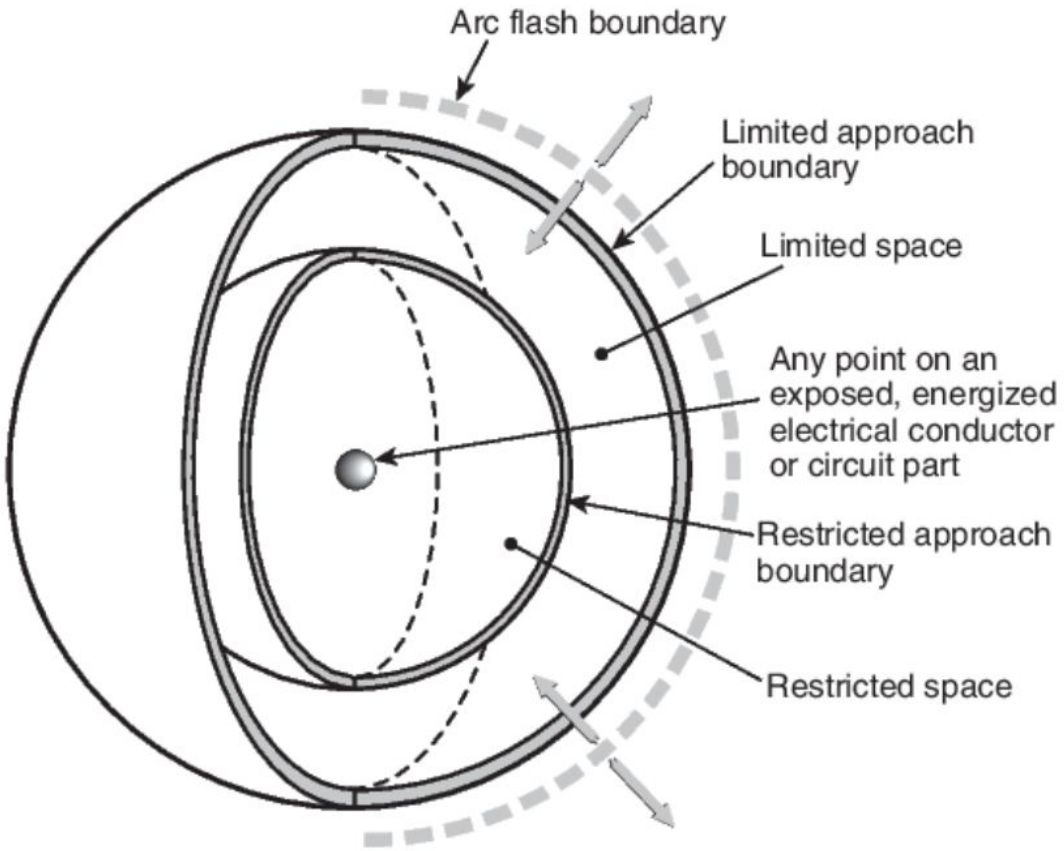


FIGURE C.1.2.3 Limits of Approach.

Risk of Arc Flash

Table 130.5(C)

Shock Hazard Boundaries

- Limited Approach Boundary
  - “Walking” Area, but hazardous.
- Restricted Approach Boundary
  - Only the working doing the work should be in this area.

Calories per Square Centimeter

- cals/cm^2
- 1.2 cals/cm^2 is the amount of thermal energy to causes 2nd degree burn.

Arc Flash Hazard Boundary

- Minimum distance where an unprotected worker can expect to receive a 2nd degree burn, if the worst case scenario happens.

One Hand Rule

- Operators
- Distance
- Controls

Distance Tables

- Limited and Restricted Approach Table 130.4(E)(a)

Arc Flash Risk Table

- Likelihood of Occurance Table 130.5(C)

Method of Calculating Arc Flash

- 130.7(C)(15) Not Recommended
- 130.5(G) Calculated by an Qualified Engineer using software. See Annex D.

LDL Process

- Visual
- NFPA 110.6(E)
- Bypasses
- Grounding
- NFPA 70E 120.6