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Your International Source for
Electrical Power Training

How to Perform an Arc Flash Hazard Calculation Study

2 Days

1.6 CEUs

Jim Phillips, P.E. is author of the book: *Complete Guide to Arc Flash Hazard Calculation Studies* and the guide: *How to Perform an Arc Flash Study in 12 Steps.* His Arc Flash Training Courses have become the industry standard. Even instructors from other training companies have attended Jim's classes to see how it's done. He takes you well beyond the usual NFPA 70E and IEEE discussions to show you how to perform arc flash calculations and conduct the detailed arc flash study. You will perform calculations of incident energy, arcing current, arc flash protection boundary and DC arc flash calculations using Jim's calculation worksheets.

What you *WILL* receive:

- Instructions on how to perform an Arc Flash Study
- Jim's AC ***AND*** DC arc flash calculation worksheets
- Training manual containing over 300 pages
- Jim's 30 page Arc Flash Calculation Guide
- Many calculation examples and problems
- 16 hours of Continuing Education Credit

What you ***<u>WILL NOT</u>*** receive:

- A commercial to sell you PPE or equipment
- A sales pitch to sell engineering study services
- A class that is just an overview or teaser

What is so special about Jim Phillips' Arc Flash Class?

Jim is not only one of the most popular and sought after instructors in the industry, he is also directly involved with the development of arc flash standards and practices. He is a member of the IEEE working group that develops *IEEE Std. 1584* ^{tm}, *IEEE Guide for Performing Arc Flash Hazard Calculations*. This enables him to go well beyond the "typical" arc flash and electrical safety class taking you behind the scenes with information about arc flash tests, interpretations, current research as well as a candid discussion of holes in the current standard and future research.

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Course Agenda
How to Perform an Arc Flash Hazard Calculation Study

HUMAN EFFECTS
Physiological Effects, Electrocution, Tissue Damage, Internal Organ Damage, Burns Fibrillation, "Curable" 2nd Degree Burn

CODES AND STANDARDS – WHICH ONE DO I USE?
OSHA Title 29 Part 1910 and 1926, NEC®, NFPA 70E, NESC, IEEE 1584™

ARC FLASH HAZARDS
Electric Shock, Arc Flash, Arc Blast, Ultraviolet Light, Sound Pressure, Burn Injury

ARC FLASH CIRCUIT DYNAMICS – FAULT CURRENT, ARC DURATION, PLASMA
Arcing Faults vs. Bolted Faults, Effect of Current on Overcurrent Device Clearing Time, Current Limitation, Effect of Transformer Size and Source Strength

NFPA 70E REQUIREMENTS
Shock and Arc Flash Hazard Analysis, Creating Energized Work Permits, Electrically Safe Working Conditions

APPROACH BOUNDARIES
Limited, Restricted, Prohibited Approach Boundaries, Arc Flash Boundary

HAZARD/RISK CATEGORIES vs. ARC FLASH CALCUATIONS
Defining the H/R Category Table 130.8(C)(15)(1), 130.8(C)(15)(2) and 130.8(C)(16), HRC 0, 1, 2, 3, 4 Requirements, Limitations of Tables, Using Calculations Instead, HRC, Tables for DC arc flash

PERSONAL PROTECTIVE EQUIPMENT PPE
Protective Clothing Characteristics, Selection of PPE, ATPV and E_{bt} Ratings, ASTM Testing Methods

ELECTRIC UTILITY ARC FLASH STUDY REQUIREMENTS AND THE NESC
Using Table 410-1 and 410-2 for Electric Utility Transmission and Distribution Systems

THE AC ARC FLASH CALCULATION STUDY USING IEEE Std. 1584™
Study Requirements, Methodology, Calculation Standards, Qualifications and Methods

DATA COLLECTION PROCESS – HOW MUCH IS ENOUGH?
Transformer, Conductor, Utility Company, Motor, Overcurrent Device, Equipment Type, Working Distance, Generator Data

Course Agenda
How to Perform an Arc Flash Hazard Calculation Study

SINGLE LINE DIAGRAM AND SYSTEM MODELING
Importance of the Up-to-Date Diagram, System Configurations, High vs. Low Fault Current, 125 kVA Transformer Exception, Motor Contribution

ARCING CURRENT CALCULATIONS, WORKSHEETS, EXAMPLE AND PROBLEMS
Arcing Current Calculations, Defining the Arc Gap Based on Equipment Type, K1 for Arcing Current in a Box vs. Open Air

ARC FLASH DURATION - TIME CURRENT CURVES
Determining the Arcing Current Clearing time, 85% vs. 100%, 2 Second Cut Off Rule, Time Current Curves, Arc Extinction

INCIDENT ENERGY CALCULATIONS, WORKSHEETS AND CLASS PROBLEMS
AC Incident Energy Calculations, Calculation Parameters, Calculation Factor Cf, Distance Exponent X, Working Distance

ARC FLASH BOUNDARY CALCULATIONS, WORKSHEETS AND CLASS PROBLEMS
Arc Flash Boundary Calculations Based on Normalized Incident Energy, Detailed IEEE Calculations, Unusually Large Boundaries, Calculation Worksheets, Problem Solving

DC ARC FLASH CALCULATIONS, WORKSHEETS, EXAMPLES AND PROBLEMS
V-I Characteristics, DC Arc Resistance Calculations, DC Incident Energy Calculations, Box vs. Open Arc Calculations, Calculation Worksheets, Problem Solving

DETERMINING PPE REQUIRMENTS FROM INCIDENT ENERGY CALCULATIONS
Using calculated incident energy to determine PPE requirements. Comparing calculations to NFPA 70E Tables, Simplifying the Selection

ARC FLASH WARNING LABELS
Requirements, Label Locations, ANSI Z535 Requirements, Signal Words and Colors

RECOMMENDATIONS TO REDUCE THE ARC FLASH HAZARD
Increase Working Distance, Remote Operation, Maintenance Settings, Arc Resistant Equipment, Current Limiting Devices, “Holes” in Present Standards, The Electrically Safe Working Condition Paradox, Future Research and Developments

STEPS TO SIMPLIFY THE ARC FLASH CALCULATION STUDY
Jim’s “What would you like the answer to be?” Approach, Simplify the Selection of PPE and Arc Flash Boundary

What is an Arc Flash?

An arc flash occurs when short circuit current flows across a gap creating an arc and can be anything from minor embarrassing sparks to a deadly explosion.

The Arc Flash is usually caused by accidental contact between energized conductors from events such as dropping a screw driver or touching a wire. It can produce temperatures in the thousands of degrees, create extreme blast pressure, launch projectiles at hundreds of miles per hour, produce ultra-violet light that can blind. It can and does kill people!

The IEEE 1584 Working Group has been studying the effects of Arc Flash through testing and analysis which lead to the development of:

IEEE Std.1584tm, IEEE Guide for Performing Arc Flash Hazard Calculations

which defines formulas and procedures used to calculate the amount of incident energy that can be released during an arcing short circuit.

Attend this class and see how to:

- **Comply** with OSHA, NFPA 70E, IEEE 1584 and NESC
- Perform many detailed AC and DC Arc Flash calculations
- Use Jim Phillips' worksheets to perform the calculations
- Simplify the Arc Flash Boundary Calculations
- Simplify the PPE selection process using IEEE calculations
- Understand the IEEE 1584 and DC arc flash equations
- Understand the importance of the working distance
- Make recommendations to reduce incident energy
- Potentially **save thousands of dollars** in short cuts

What is an Arc Flash Hazard Calculation Study?

NFPA 70E Section 130.5(B) requires that an arc flash hazard analysis "shall determine, and the employer shall document, the incident energy exposure of the worker (in calories per square centimeter). The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. It further states that "…Arc-rated clothing and other personal protective equipment (PPE) shall be used by the employee based on the incident energy exposure associated with the specific task."

NFPA 70E also requires determining the arc flash boundary, which is the distance from a potential arc source where the incident energy is 1.2 cal/cm^2. This value is considered to be the point at which the onset of a second-degree burn occurs. Live work performed outside of the flash boundary does not require PPE, although the risk of some injury still exists.

The concept of these requirements is simple. At each location, the arc flash study is used to determine:

- The prospective incident energy exposure for a worker's chest and face.
- The level of PPE is based on the prospective incident energy.
- The arc flash boundary.

Although NFPA 70E provides more generalized hazard risk tables as a simplified alternative for PPE selection, an arc flash study requires performing calculations to estimate the magnitude of incident energy exposure. These calculations are based on specific details, including the available short circuit current, device clearing time, grounding, arc gap distance, equipment type, and many other factors. The results are used to determine the arc flash boundary and required level of PPE.

This information, as well as data regarding electric shock protection and approach limits, can be included on the arc flash warning labels placed on the equipment under study. Before conducting energized work, a qualified worker can refer to the label and obtain all of the data necessary for the shock hazard analysis and flash hazard analysis required by NFPA 70E.

Although an arc flash study can appear to be complex, it can be more manageable when broken down into basic steps as outlined in this training program.

Why perform an Arc Flash Study?

According to OSHA 1910.132(d) The employer is responsible to assess the hazards in the work place, select, have, and use the correct Personal Protective Equipment (PPE) and document the assessment. The use of NFPA 70E and other related industry consensus standards has been used to demonstrate whether an employer acted reasonably when there is a possible OSHA enforcement action taken.

So although NFPA 70E is not directly part of OSHA standards, it can be used as evidence of whether an employer acted reasonably in complying with OSHA standards and addressing "recognized hazards".

There are more specific links within the OSHA standards as well. A typical example is found in 1910.335, Safeguards for personnel protection which requires:

> *"(a)(1)(i) Employees working in areas where there are potential electrical hazards shall be provided with, and shall use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed."*

This regulation requires that employees must be properly protected from potential electrical hazards, by using adequate PPE, but it does not provide specific detail of what specific personal protective equipment is necessary to achieve the objective. It might be considered that based on this generalized statement, the selection of the correct PPE is open to interpretation however, this would be incorrect and an Arc Flash study should be performed.

Jim, in the high power lab setting up an arc flash test on a pad mounted transformer.

A side trip to the high power lab during an IEC meeting in Frankfurt Germany.

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Receive answers to these questions and more:

- How do I organize a study?
- What equipment really needs labeled?
- Where do I obtain the required data?
- How much information is really required on the arc flash label?
- Do I need all data such as conductor lengths?
- How do I calculate AC incident energy, arcing current & arc flash boundary?
- What is the difference between low voltage and medium voltage calculations?
- How do I calculate DC incident energy from an arc flash?
- How do I calculate DC arc resistance and what is a V-I characteristic?
- How accurate are the IEEE 1584 calculations?
- Can I mix NFPA 70E Tables 130.8(C)(15)(1) & (2) with arc flash calculations?
- What PPE should I wear when I am gathering data to study what PPE I should wear?
- Why do I also have to analyze arc flash during for minimum fault currents?
- What very important question do I ask the electric utility?
- Are time current curves a reliable way to determine arc flash clearing time?
- What if I have a low arcing current that causes a long clearing time?
- Is the 125 kVA 208V cutoff discussed in IEEE 1584 appropriate?
- Is the "2 second rule" appropriate?
- How long can an arc sustain itself? - ***discussion of recent test data***.
- How do I use the NESC Table 410.1 and 410.2 for electric utility systems?
- Why do I use a comparison of 100% and 85% of the arcing current?
- Does the type of equipment make a difference in the calculations?
- What about grounded vs. ungrounded systems?
- What about Arc Blast and the 40 calories / cm^2 upper limit? – Is it realistic?
- How do I include motor contribution to the calculations?
- What are the Calculation Factor C_f and Distance Exponent Factor X?
- How do I greatly simplify the Arc Flash Protection Boundary and PPE selection?
- How can current limiting devices reduce the incident energy?
- Why use remote operation, arc resistant equipment, and maintenance switches?
- Why is selecting the correct working distance an important part of the calculations?
- What are Jim's latest tests and what are plans for the next revision to IEEE 1584?
- Why is the *L/E ratio* ™ so important?

Jim Phillips, P.E.

Member of IEEE 1584 *IEEE Guide for Performing Arc Flash Hazard Calculations*

Vice - Chairman of Task Group - *IEEE 1584.1 Guide for the specification of scope and deliverable requirements for an arc-flash hazard calculation.*

Member of IEC 61482-1-2 Determination of arc protection class of material and clothing by using a constrained and directed arc (box test)

Author of the book: *Complete Guide to Arc Flash Hazard Calculation Studies*

Is a regular contributor to Electrical Contractor

Founder of the internationally known website: www.ArcFlashForum.com

For 30 years, Jim has been helping tens of thousands of people around the world understand electrical power systems design, safety, theory and applications. Having taught over 2000 seminars during his career to people from all seven continents (Yes Antarctica is included!), he has developed a reputation for being one of the best trainers and public speakers in the industry.

Jim does not just talk about arc flash and electrical safety - he is part of the development of the arc flash standards! He is also the instructor that has taught other instructors in the industry. Jim is a member of the IEEE 1584 Committee - *IEEE Guide for Performing Arc Flash Hazard Calculations.* He is Vice-Chairman of the IEEE Task Group - IEEE 1584.1 "Guide for the specification of scope and deliverable requirements for an arc-flash hazard calculation study in accordance with IEEE 1584"

Jim literally wrote the book about arc flash studies with his book titled: ***Complete Guide to Arc Flash Hazard Calculation Studies*** available from brainfiller.com and Amazon.com He also wrote "How to Perform an Arc Flash Study in 12 Steps" published by NFPA.

In addition to being a regular contributor to Electrical Contractor Magazine, he was one of the main contributors for the NEC Digest. He has authored many articles published in Europe and is a regular speaker at conferences around the world.

Jim earned a BS Degree in Electrical Engineering from the Ohio State University. His career began with Square D Company's Power System Analysis Group where he was responsible for system studies, power system software development and training at their engineering programs.

Later, Jim was in charge of the studies group of the System Protection Section of Ohio Edison Company. He was part of the adjunct faculty for Stark State College where he taught evening classes in electrical power systems.

Jim is a Registered Professional Engineer. with experience that includes everything from planning transmission systems, to design and analysis of industrial, commercial and utility power systems, cogeneration plant design, expert witness and forensic analysis.

Jim continues to travel the globe typically flying over 150,000 miles a year to work with various U.S. and international standards organizations and speak at many conferences and training events.