

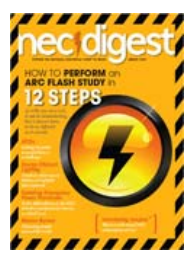


T₂G TECHNICAL TRAINING GROUP®

Arc Flash Studies

How to Perform an Arc Flash Study for Electric Utilities Based on Jim Phillips, PE's guide published in NFPA's NEC Digest

Jim Phillips, P.E. is author of 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 NESC, IEEE, NESC and NFPA 70E, discussions to show you how to perform arc flash calculations and conduct the detailed arc flash study. You will analyze **medium voltage equipment, overhead distribution lines** and see how to interpret NESC Table 410-1 and 410-2 using Jim's worksheets that are based on IEEE 1584. **Learn how to perform the detailed study yourself and save tens of thousands of dollars. Get your company into compliance today!** 2 Days - 1.6 CEUs or 16 PDHs



What you **WILL** receive:

- Instructions on how to perform an Arc Flash Study
- Jim's arc flash calculation worksheets
- 2 training manuals containing over 300 pages
- Jim's 30 page Arc Flash Calculation Guide
- Many calculation examples and problems
- "How to Perform an Arc Flash Study in 12 Steps"
- 16 hours of Continuing Education Credit

What you **WILL NOT** 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. 1584tm, 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 very candid discussion of holes in the current standard and the direction of future research.

Jim wrote the guide: "*How to Conduct an Arc Flash Study in 12 Steps*" which is published by NFPA's NEC Digest. He also serves on the Electrical Safety Week Conference Committee which is held early each year.



Biography

Jim Phillips, P.E.

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

Co-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*

Author of the book: *How to Perform an Arc Flash Calculation Study* available from NFPA's publisher Jones and Bartlett late 2009.

Has a regular column in Electrical Contractor Magazine *Arc Flash - Unplugged*

Founder of the internationally known website www.ArcFlashForum.com

For almost 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 almost 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 electric power industry.

Jim does not just talk about arc flash and electrical safety - he is part of the development of the actual 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* which is the predominant method for performing arc flash calculation studies. He is Co-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"

He wrote "How to Perform an Arc Flash Study in 12 Steps" which was published by the NFPA. He just completed the book "How to Perform an Arc Flash Calculation Study" that will be released later in 2009 by NFPA's publisher. This book is a step by step approach for conducting the arc flash study and it answers many of the controversial questions about the codes and standards.

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Jim created the internationally known website www.ArcFlashForum.com which is used by the global community for understanding arc flash and electrical safety.

He writes a regular column titled *Arc Flash - Unplugged* for Electrical Contractor Magazine and previously was one of the main writers for the NEC Digest. He also authored several articles published in Europe as well as speaking at several European conferences about Arc Flash.

Throughout his career he has served on many committees including the Energy Policy Committee of IEEE in Washington DC. He is a member of The National Fire Protection Association - NFPA, The Power Engineering Society and the Industry Applications Society.

Jim earned a BSEE Degree in Electrical Engineering at the Ohio State University. After Ohio State, his first job was 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 training programs. Jim is a Registered Professional Engineer in Ohio and Kentucky.

Later, Jim worked for Ohio Edison Company where he headed up the studies group of the System Protection Section. While working for Ohio Edison, he was part of the adjunct faculty for Stark State College where he taught evening classes in electrical power systems. Jim's experiences have included everything from planning transmission systems, to design and analysis of industrial and commercial power systems and cogeneration plants.

Jim's experiences have included everything from planning transmission systems, to design and analysis of industrial and commercial power systems and cogeneration plants. His teaching experience ultimately led to the creation of T2G Technical Training Group in the 1980's which provides training programs, videos and continuing education on a wide array of electrical power system topics.



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

How to Perform an Arc Flash Study for Electric Utilities

Jim Phillips, P.E.



Jim at TVPPA's Utility Conference showing how it's done!

Attend this class and see how to:

- **Comply** with OSHA, NESC, NFPA 70E and IEEE 1584
- Perform the detailed Arc Flash study yourself
or ...
- Know what questions to ask Arc Flash consultants
- Define the Arc Flash study scope
- Develop your Electrical Safety Program
- Determine required PPE from IEEE calculations
- Potentially **save thousands of dollars** in short cuts

Receive answers to these questions and more:

- What about the **NESC's January 1, 2009** deadline?
- What are the NESC requirements
- How do I use the NESC Table 410.1 and 410.2?
- Can I use NFPA 70E Table 130.7(C)(9)(a) for the study?
- Is it better to use detailed IEEE 1584 calculations?
- How do I organize a study?
- What equipment really needs labeled?
- Where do I obtain the required data?
- Are detailed arc flash labels with incident energy and boundaries required?
- Do I need all data such as conductor lengths?
- Are the IEEE calculations accurate?
- What PPE should I wear when I am gathering data to study what PPE I should wear?
- Do I base the study on maximum fault currents?
- 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?
- Why was the 125 kVA 208V cutoff discussed in IEEE 1584?
- Is the "2 second rule" appropriate?
- How long can an arc sustain itself? - **discussion of recent test data.**
- Why does IEEE 1584a 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 single phase arc flash on overhead lines?
- What about Arc Blast?
- Is 40 Calories / cm² really an upper limit?
- Do I include motor contribution?
- What is the Calculation Factor C_f and when do I use it?
- How do I handle emergency generators?
- How can current limiting devices reduce the incident energy?
- Should I specify arc resistant equipment?
- How can I convince electrical workers and management of the study's importance?
- What tests are planned for the next revision to IEEE 1584?
- Why is the L/E ratiotm so important?



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How to Perform an Arc Flash Study for Electric Utilities

Jim Phillips, P.E.



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.

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, NESC 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 and NESC are 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.

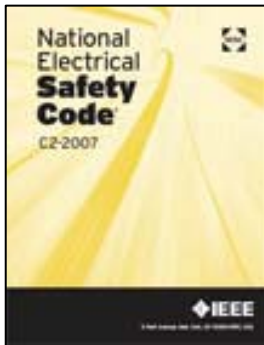
How to Perform an Arc Flash Study for Electric Utilities

Jim Phillips, P.E.

What is an Arc Flash Calculation Study?

NFPA 70E Section 130.3(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 "...flame-resistant (FR) clothing and personal protective equipment (PPE) shall be used by the employee based on the incident energy exposure associated with the specific task."

 WARNING	
Arc Flash and Shock Hazard Appropriate PPE Required	
2' - 0" 2.3 #1	Flash Hazard Boundary cal/cm ² Flash Hazard at 18 Inches PPE Level FR shirt and FR pants or FR coverall
0.48 3' - 6" 1' - 0" 0' - 1"	kV Shock Hazard when cover is removed Limited Approach Restricted Approach - Class 00 Voltage Gloves Prohibited Approach - Class 00 Voltage Gloves
Equipment Name: PNL-3 (Fed by: BL-2) www.brainfiller.com	



The **National Electrical Safety Code (NESC) Section 410.3**, states that effective January 1, 2009 the employee shall ensure that an assessment is performed to determine potential exposure to an electric arc for employees who work on or near energized parts or equipment. This can be accomplished by either using NESC Table 410-1 and 410-2 or performing an arc hazard analysis.

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

- The incident energy exposure for a worker's chest and face if an arc flash occurs.
- The level of PPE a worker must wear based on the possible incident energy exposure.
- The flash protection boundary.

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

Performing an Arc Flash study can appear to be an overwhelming project however, it can be more easily managed when broken down into the 12 basic steps listed at the bottom of the next page.

How to Perform an Arc Flash Study for Electric Utilities

Jim Phillips, P.E.

On Site Training - Have This Course at Your Location!

Hold this class at your location for a greater savings. For an all inclusive fee you receive the following for each attendee:

- Jim Phillips, P.E. as the course instructor
- Details on how to perform an Arc Flash Study
- Jim's arc flash calculation worksheets
- 2 training manuals containing over 300 pages
- "How to Perform an Arc Flash Study in 12 Steps"
- Jim's 30 page Arc Flash Calculation Guide
- 16 hours of Continuing Education Credit



Call Brenda at 800-874-8883 **today** for an On-Site Training Proposal!
Jim's schedule usually fills up months in advance!

How to Perform an Arc Flash Study for Electric Utilities

1. Data Collection Process
2. Develop Single Line Diagram
3. System Modeling
4. Arcing Short Circuit Calculations
5. Time Current Curve Evaluation
6. Incident Energy Calculations
7. Flash Protection Boundary Calculations
8. Determine Personal Protective Equipment Requirements
9. Create Arc Flash Warning Labels
10. Develop the Report and Recommendations
11. Integrate the Study into the Electrical Safety Program
12. Training Affected Personnel



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Jim Phillips, P.E.

HUMAN EFFECTS

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

CODES AND STANDARDS

OSHA Title 29 CFR - Part 1910, NFPA 70, NESC, NFPA 70E, IEEE Standard 1584™

CATEGORIES OF ELECTRICAL HAZARDS

Electric Shock, Arc Flash, Arc Blast, Ultraviolet Light, Sound Pressure, Categories of Burns

ELECTRICAL CIRCUIT DYNAMICS

Arcing Faults vs. Bolted Faults, Effect of Current on Overcurrent Device Clearing Time, Current Limitation

NFPA 70E REQUIREMENTS

Shock and Flash Hazard Analysis, Creating Energized Work Permits, Electrically Safe Conditions

APPROACH BOUNDARIES

Limited, Restricted, Prohibited & Flash Protection Boundary

HAZARD/RISK CATEGORY

Defining the HR Category by cal/cm² Class 0, 1, 2, 3, 4 Requirements, Table Footnote Limitations

PERSONAL PROTECTIVE EQUIPMENT PPE

Protective Clothing Characteristics, ATPV Ratings, ASTM Testing

NESC AND ELECTRIC UTILITY REQUIREMENTS

Table 410-1 and 410-2, January 1, 2009 Deadline, Study Requirements, Overhead Lines vs. Equipment

PERFORMING THE DETAILED ARC FLASH STUDY

Study Requirements, Methodology, Configuration, Arc Flash in Open Air vs. Equipment Enclosure

STEP 1 - DATA COLLECTION

Transformer, Conductor, Source, Motor, Relays, Breakers and Fuses, Generator Data

STEP 2 - DEVELOP THE SINGLE LINE DRAWING

STEP 3 - SYSTEM MODELING FOR ARC FLASH STUDY

High vs. Low Fault Current, System Configuration, 125 kVA Transformer Limit, 1 Phase vs. 3 Phase Arc Flash

STEP 4 - IEEE Std. 1584™ - ARCING CURRENT CALCULATIONS

Arcing Current Calculations, Defining the Arc Gap Based on Equipment Type, K1 for Arc in Box vs. Air

STEP 5 - TIME CURRENT CURVES

Determining the arcing current clearing time, 85% vs. 100%, 2 Second Cut Off Interpretation

STEP 6 - IEEE Std. 1584™ - INCIDENT ENERGY CALCULATIONS

Incident Energy Calculations, K2 and Effect of Grounding, Impact of Device Settings

STEP 7 - IEEE Std. 1584™ - FLASH PROTECTION BOUNDARY CALCULATIONS

Flash Protection Boundary Calculations Based on Incident Energy, Calculation Factor Cf, Distance Factor X, 4 ft. rule vs. Detailed IEEE Calculations, Unusually Large Boundaries

STEP 8 - DETERMINING PPE REQUIREMENTS

Using calculated incident energy to determine PPE. Comparing this method to 70E and NESC Tables.

STEP 9 - ARC FLASH WARNING LABELS

Labeling Requirements, Approach Boundaries, Class of PPE, Standardizing Labels and Practices

STEP 10 - REPORT AND RECOMMENDATIONS

Reducing Incident Energy, Relay and Device Setting Changes, Arc Resistant Switchgear, Design and Operating Changes, Current Limiting Devices, "Holes" in Present Standards.

STEP 11 - INTEGRATE THE STUDY INTO THE ELECTRICAL SAFETY PROGRAM

Interpreting the Arc Flash Labels, PPE and Boundaries for Simplified Electrical Safety Practices.

STEP 12 - TRAINING AFFECTED PERSONNEL