IEEE 1584-2018 D6
Guide for Performing Arc-Flash Hazard Calculations

Victor Andrade - ETAP
Principle Power Engineer

AGENDA

- Arc-Flash Phenomena Research and Tests
- Arc-Flash Model Development and Validation
- IEEE 1584-2018 Arc-Flash Model Range
- Arc Current and Variation Correction Factor
- Enclosure Size Correction Factor

AGENDA

- Effect of Equipment Grounding and Bonding
- Low Voltage 240 Volt / 125 kVA Exception
- Identification of Electrode Configurations
- Applying the Arc-Flash Model in ETAP
- IEEE 1584 Arc-Flash Calculator

Arc-Flash Phenomena Research and Tests

Arc-Flash Phenomena Research and Tests

- The IEEE **1584-2002** arc-flash model used ~ **300** tests
- The IEEE **1584-2018** model used over **1800** tests
- IEEE 1584-2002 test results were also used in new model
- Tests included **6** configurations of which **5** were used
- **Five** different labs were used for performing the tests
- Tests -> Diff. Voltages (0.208 to 15 kV), gaps, current, box sizes

Arc-Flash Phenomena Research and Tests

Overall Test Count by Electrode Configuration:

Electrode Configuration	Tests Performed	Voltage Range	Current Range	Gap Range
VCB	485	0.208 ~ 14.8 kV	0.5 ~ 80 kA	6 ~ 250 mm
VCBB	400	0.215 ~ 14.8 kV	0.5 ~ 65 kA	6 ~ 154 mm
HCB	460	0.215 ~ 14.8 kV	0.5 ~ 63 kA	10 ~ 254 mm
VOA	251	0.240 ~ 14.8 kV	0.5 ~ 65 kA	10 ~ 154 mm
HOA	259	0.240 ~ 14.8 kV	0.5 ~ 66 kA	10 ~ 154 mm
HCB-CT*	40	12 kV	5 ~ 10 kA	254 mm

*Not included in final IEEE 1584-2018 D6 Arc-Flash Model

Arc-Flash Phenomena Research and Tests

- Intensity of light emitted by arc can reach 1 million lux
- Sound level can reach 140 dB (NFPA 70E)
- Electrode material (Cu/Al) thermal energy release and shrapnel ejected from arc jets exhibit different physical behavior
- Pressure wave measurements define arc-blast hazard

Arc-Flash Model Development and Validation

Arc-Flash Model Development & Validation

- The model developed is an empirical model
- Arc current was processed based on the average value of all three phases minus the first and last cycles of data
- Incident energy per cycle was measured and ….
- Sensitivity analysis was performed to determine the effect of each parameter
- Statistical analysis was performed to determine correction factors for arc current and enclosure size effects

Arc-Flash Model Development & Validation

Model Validation Process Overview

1. Review of Data Processing and Model Creation Methods
2. Creation of Prototype Validation Tools
3. Establishment of Model Performance Metrics (benchmarks)
   - Iterative comparisons of model output against test data
   - Comparisons against IEEE 1584-2002
   - Factoring the “expected” arc physical behavior
4. Determination of the Final Model Application Range

Range of the IEEE 1584-2018 Arc-Flash Model

IEEE 1584-2018 Arc Sustainability

No more LEE Method Recommendation…!

"There are alternative calculation methods for system parameters which fall outside the range of the model. However, no particular recommendation can be made since there are other application details such as bolted fault current levels, voltage, gap length, operating frequency, number of phases, types of faults, etc., etc. The user is advised to properly research alternative calculation methods an their application viability"

Arc Current and Variation Correction Factor

Effect of Equipment Grounding and Bonding

Enclosure Size Correction Factor

Effect of Grounding & Bonding

- **IEEE 1584-2002** equations factored the effect of system grounding with an overall ~ **± 15% Δ on the I.E**.
- In **IEEE 1584-2018**, the system grounding **is not a factor** in the equations (i.e. no effect on the measured I.E.).
- Similarly **bonded or un-bonded** enclosures did not show significant effect on the measured I.E.
- Ground current flows as arc is most likely to start as LG but should decay to negligible values as soon as arc becomes three-phase (in less than 1 cycle)

Low Voltage Arc Sustainability (208 Volts - 125 kVA Exception)

IEEE 1584-2018 Arc Sustainability

- Additional configurations such as **VCBB** used in testing reveal that arcs can sustain at **much lower** short-circuit current values than what was originally presented in IEEE 1584-2002
- It is difficult to determine an absolute **low-end arc-sustainability** condition (lab test setup vs. actual equipment)
- The **new statement on low voltage sustainability** was derived based on additional testing performed in low-voltage test configurations including three-phase, single-phase, copper and aluminum
- Conductor materials such as **aluminum** are more common in low-voltage equipment, yet not considered in this guide

IEEE 1584-2018 Arc Sustainability

The new low-voltage sustainability statement:

"Sustainable arcs are less likely in three-phase systems operating at 240 V nominal or less with an available current below 2000 A"

Identification of Electrode Configurations in Equipment

Identifying Electrode Configurations

- The electrode configuration (EC) selection is the first step in the application of the model
- Matching the EC to actual equipment can be challenging
- Magnetic fields influence the trajectory of the plasma, molecular cloud and ejected material at the arc jets

Identifying Electrode Configurations

- Table 9 from IEEE 1584-2018 Draft D6 (purchased from IEEE website for the purpose of this presentation) is a good starting point for examples of the identification process
- There may be more than one EC in any one location and the arc-flash EC mode can change from inception

Applying the AF Model in Power System Analysis Software

IEEE 1584
AF Calculator

Questions?