IEEE 1584

Development of the Standard

hood patterson & dewar

About the Presenter

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- OSHA Authorized General Industry Trainer
- Member of the IEEE 1584 voting committee
- Participating member on the IEEE IAS Electrical Safety Committee

Brief History Electrical Safety

We've Come a Long Way...

Alessandro Volta,
1745-1827

"I introduced into my ears two metal rods with rounded ends and joined them to the terminals of the apparatus.

At the moment the circuit was completed, I received a shock in the head – and began to hear a noise – a crackling and boiling.

This disagreeable sensation, which I feared might be dangerous, has deterred me so that I have not repeated the experiment."

“Safety Standard”

1952 American Electricians Handbook

- Electricians to test for voltage by touching conductors with their fingers
- Considered a “safe” and “convenient” method
  - (for voltage < 250)
- Warns that “some men” can tolerate it better than others

Real Standards Were Born

From the 70s into the New Millennium

- OSHA established
  - Nixon signs into law in 1971
- NFPA-70E
  - Committee formed in 1976
- 4th Edition of NFPA-70E, 1988
  - Became OSHA Subpart S – Electrical in 1991

Dupont's Lead

Theory in Practice: 1980s

- Company had some severe arc flashes
- Developed an electrical safety team

The Lee Equations

Ralph Lee and Modern Arc Flash Theory

- In 1982, authored “The Other Electrical Hazard: Electrical Arc Blast Burns”
  - Considered the beginning of modern electrical arc flash theory
  - Quantified potential burn hazards, raised safety awareness
  - Established a method to estimate the amount of incident energy produced by electrical arcs and the energy threshold (e.g. 96°C at 0.1 sec) to produce a “just curable burn” of the human body
  - Much of today’s arc flash protection practices are based on Lee’s earlier efforts

Incident Energy (IE) Calculations

Testing Methodology

- Richard L. Doughty, Thomas E. Neal and H. Landis Floyd II
- In 2000, “Predicting Incident Energy to Better Manage the Electric Arc Hazard on 600V Power Distribution Systems”
  - Arc flash severity defined by amount of incident energy
  - Calories/centimeter Squared (cal/cm^2) that could reach a worker
  - Provided detailed calculation methods to predict prospective incident energy

Incident Energy (IE) Calculations

Testing Methodology

Theory in Practice

Turn of the Century

- 1584 was born
  - Decided on wide range of currents and voltages
  - Raised ~$75,000 in funding
  - Used 20 cubic inch box
  - Tested MCC's using a smaller size box
  - Testing facilities – Square D in Cedar Rapids & Ontario Hydro in Toronto
  - Bussmann played a big roll as well
- Navy got involved
  - Wanted to see how an arc flash would damage ship
  - Built a 15' cube
  - Obtained funding for 13.8kV testing
- Completed document went through a robust approval process
  - Three rounds of 100s of questions
  - Approved June 2002 (2 year cycle)

IEEE 1584-2002

Developing the 2002 Revision

- Based on the results of > 300 arc flash tests
- Four calculation methods:
  1. Systems less than 1000 V
  2. Systems from 1000 to 15,000 V
  3. Incident energy (cal/cm2)
  4. Flash hazard boundary (AKA arc flash boundary)
- 85% rule
  - Slow burn vs. Rapid Energy Release
- 125kVA transformer rule
  - Based on data, would not sustain an arc
- 2-second rule
  - Would leave the arc with-in two seconds

Electrical Fatalities since the 1990s

Workplace fatalities declined 41%

Dawn of the Revised Standard

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Revision Process Begins

Questions immediately arose

1. What if the electrodes were horizontal instead of vertical
2. What about difference size enclosures
3. What about DC arc flash?

PCIC established a collaboration committee between IEEE and NFPA

- Raised ~$6 Million
- Recommended 10-year Project Authorization Request (PAR)

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Other Parameters

- Blast Pressure
  - Injury potential based on fault level
    - Slow burn vs. Rapid Energy Release
- Sound Pressure
  - Risk of severe hearing damage
  - Tests at 4,160 volts have produced sound levels upwards of 160 dB at distances of more than 3-meters
- Light
  - Bright summer day is 100,000 lux (light intensity)
    - 1 lux= 1 lumen per square metre squared
  - Tens of millions of lux have been measured during arc flash testing
- Enclosure Size (now a variable)
  - Based on standard NEMA sizes

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Arc Gaps are now Variables

IEEE-1584 - 2002

Classes of equipment	Typical Bus gaps (mm)	Typical bus gaps (in)
15 kV Switchgear	152mm	5.98
5 kV Switchgear	104	1.10
Low-voltage switchgear	32	1.26
Low-voltage MCCs and panelboards	25	0.98
Cable	13	0.51
Other	Not required	N/A

Proposed Sample New Gap Sizes

Rated Voltage (V)	Bolted Fault Min/Max (Amps)	Gap Min / Max (Inches)
208V	2,500A / 100,000A	0.25in / 0.75in
13,800V	500A / 63,000A	3.0in / 6.0in

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Test Configurations

The 1584 Committee decided to conduct tests using five configurations

- VCB – Vertical electrodes in a Cubic Box (IEEE 2002)
- VCBB – Vertical electrodes in a Cubic Box terminated in a “Barrier”
- HCB – Horizontal electrodes in a Cubic Box
- VOA – Vertical electrodes in Open Air (IEEE 2002)
- HOA – Horizontal electrodes in Open Air

Arc Flash

HCB Configuration

Arc Flash

VOA Configuration

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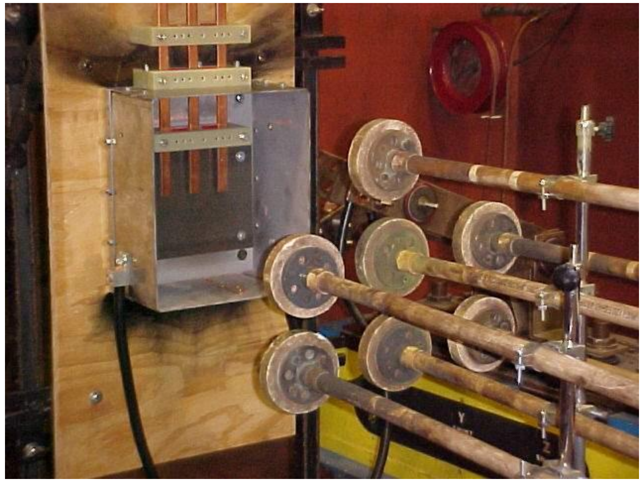
1700 Tests Conducted

Voltage	~ Number of tests
208V (3ph) 240V (1ph)	195
480V	400
600V	340
2700V	320
4160V	180
14.3kV	270



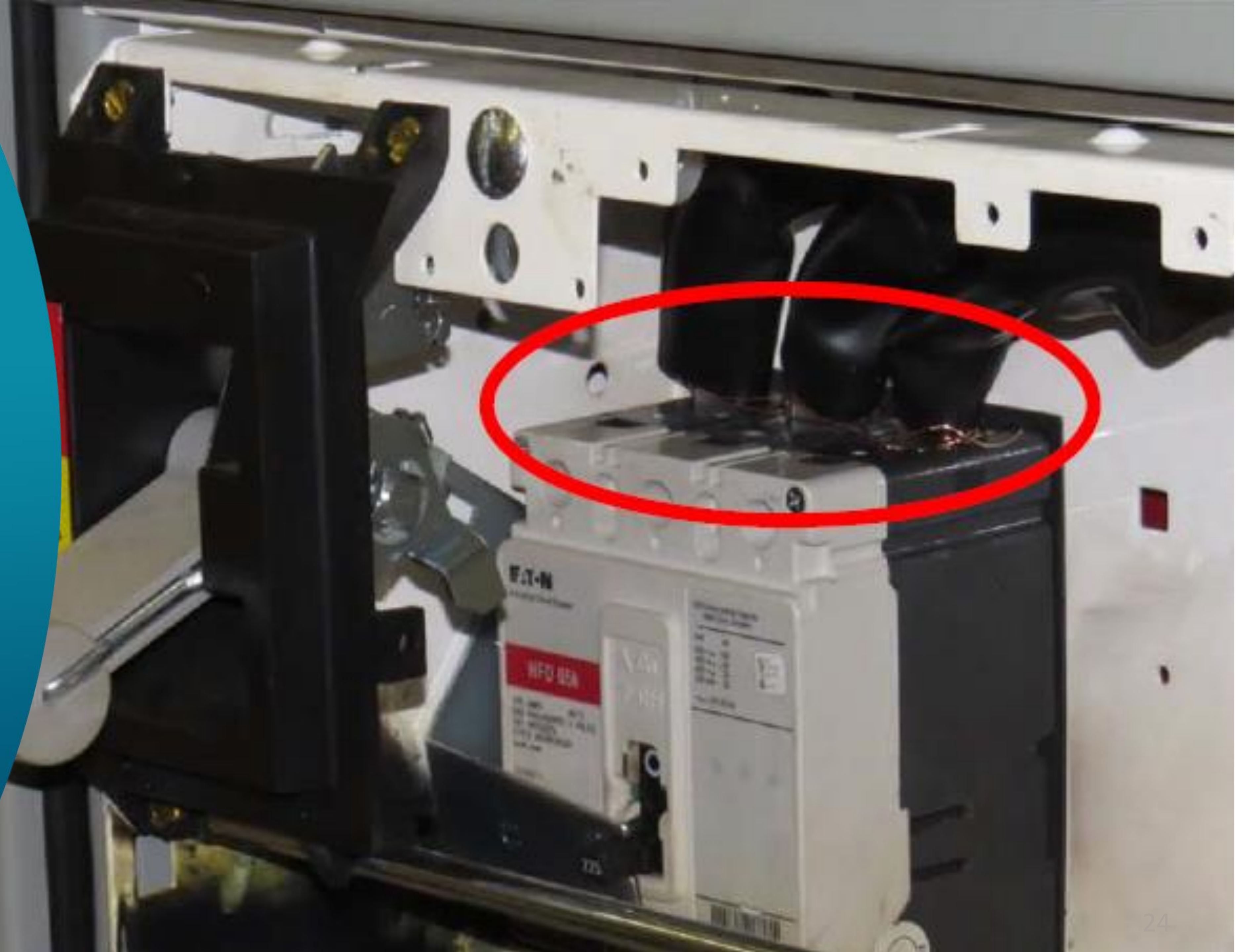
Arc Flash

VCB Configuration

Load side of BKR

Arc Flash

VCBB
Configuration

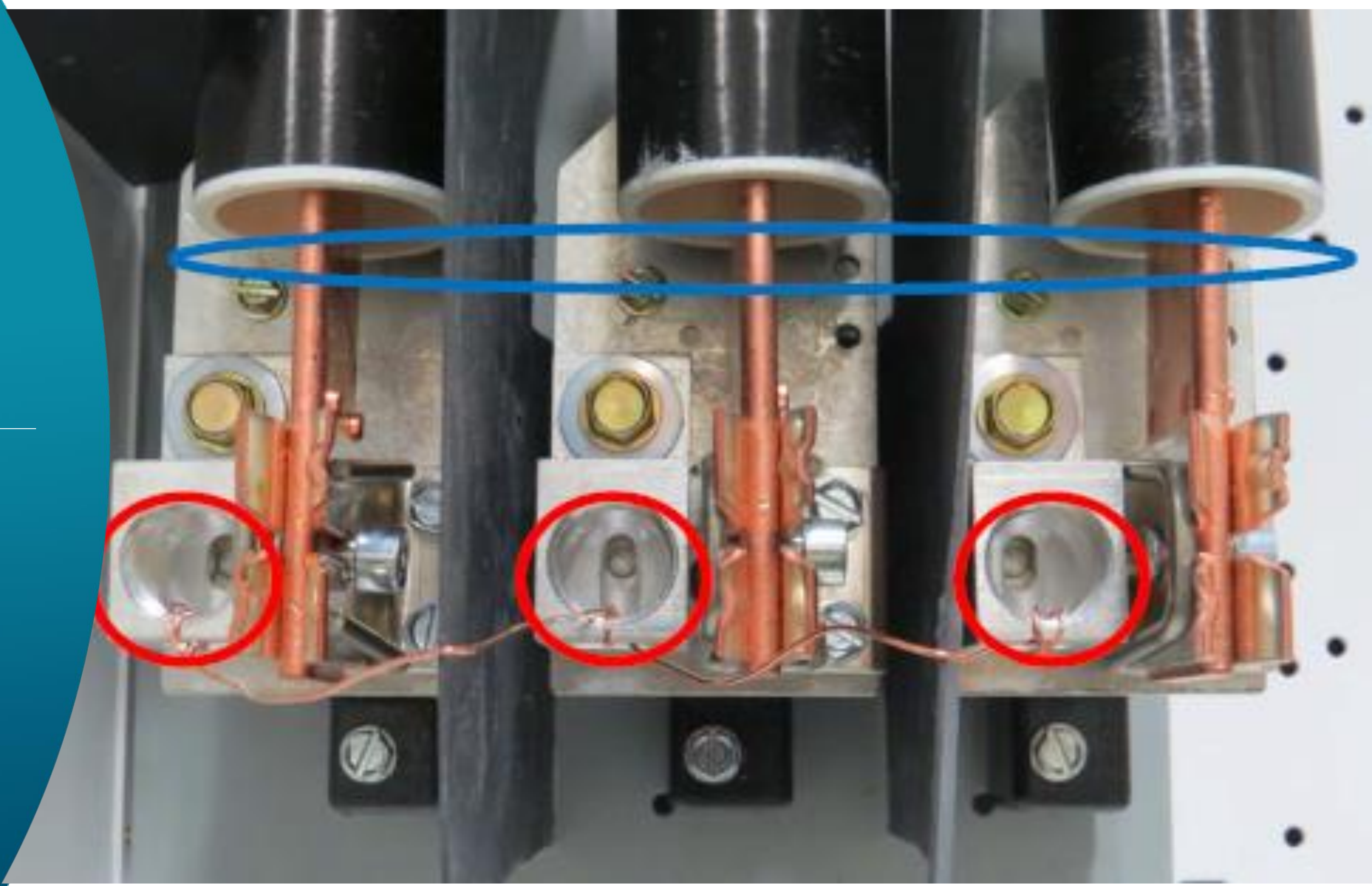


Arc Flash

HCB /HOA Configuration

Arc Flash

VCB (blue),
HCB /HOA (Red)
Configuration



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Study Complexity

- New standard makes modeling more complex
- Proposed variables
  - Configurations (VCB, VCBB, HCB, VOA, HOA)
  - Voc
  - Ibf
  - Working Distance
  - Duration (Breaker or fuse curve)
  - Gap
  - Enclosure Size
    - Box Size & Gap defaults to conservative NEMA size and gap distance

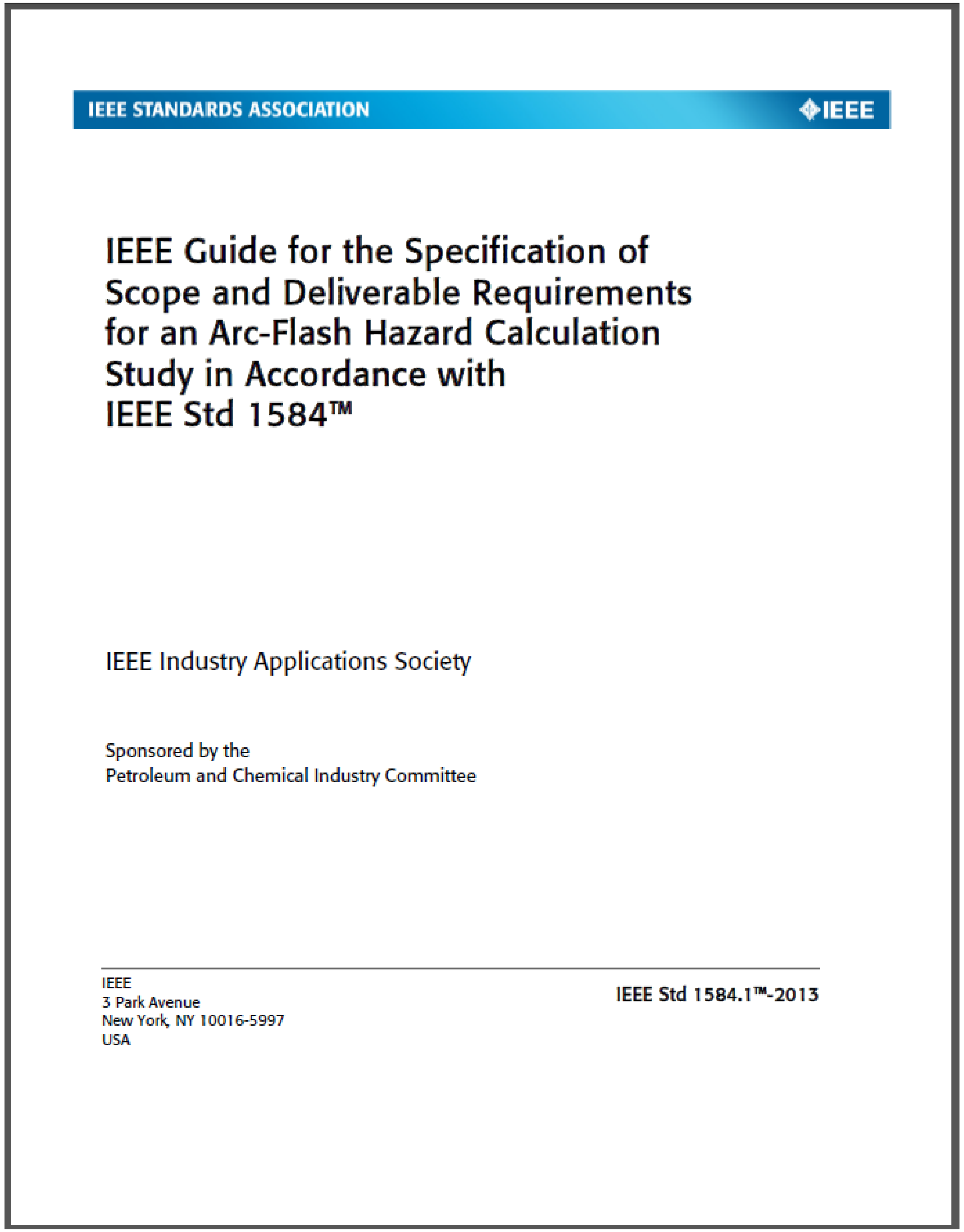
Study Complexity

Standard practices taken out

- 125kVA Rule will not be in the new text
  - Instead a proposal was made – *"No tests were done at 250V and less than 2500A, therefore should not be considered."*
- 85% rule will not be in new text
  - Statistical deviation was such that confidence in formulas
  - So no need to have this rule
- 2 second rule will not be in new text

IEEE-1584.1

The How-to Standard



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IEEE Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study in Accordance with IEEE Std 1584™

IEEE Industry Applications Society

Sponsored by the
Petroleum and Chemical Industry Committee

IEEE
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New York, NY 10016-5997
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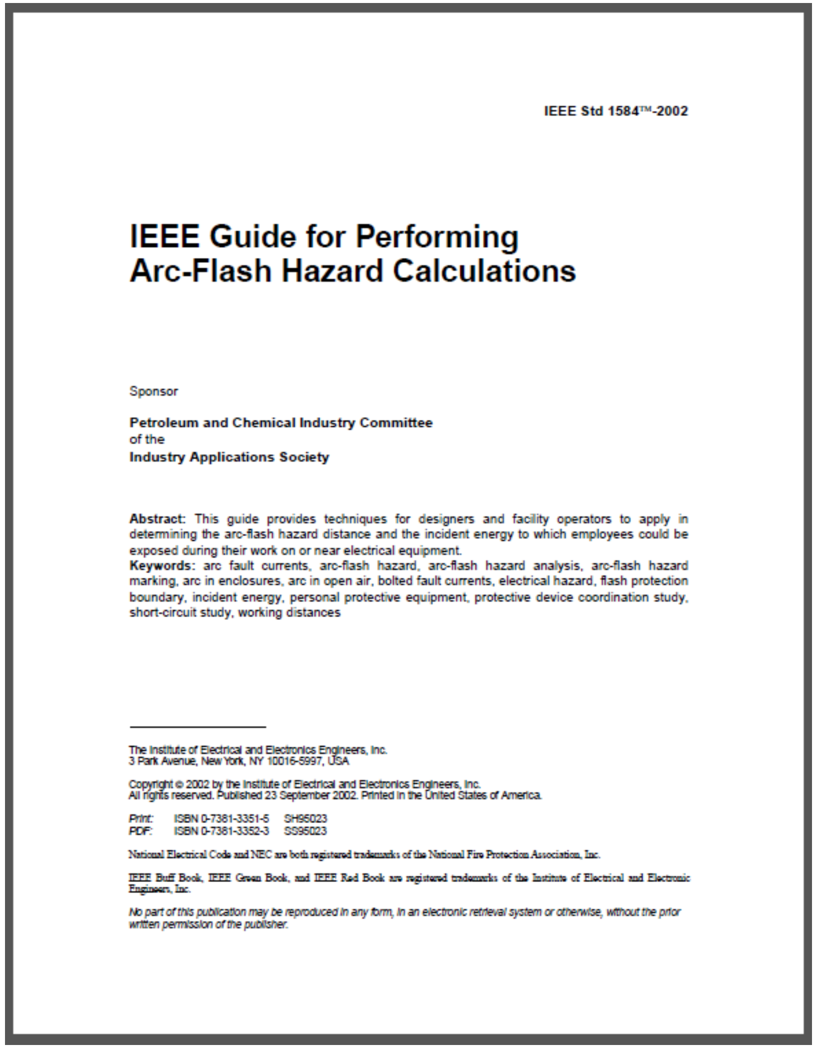
IEEE Std 1584.1™-2013

Concerns moving forward

The Politics and Complexity of Creating a Standard

IEEE 1584 and 1584.1

Two Documents



IEEE Std 1584™-2002

IEEE Guide for Performing Arc-Flash Hazard Calculations

Sponsor

Petroleum and Chemical Industry Committee
of the
Industry Applications Society

Abstract: This guide provides techniques for designers and facility operators to apply in determining the arc-flash hazard distance and the incident energy to which employees could be exposed during their work on or near electrical equipment.
Keywords: arc fault currents, arc-flash hazard, arc-flash hazard analysis, arc-flash hazard marking, arc in enclosures, arc in open air, bolted fault currents, electrical hazard, flash protection boundary, incident energy, personal protective equipment, protective device coordination study, short-circuit study, working distances

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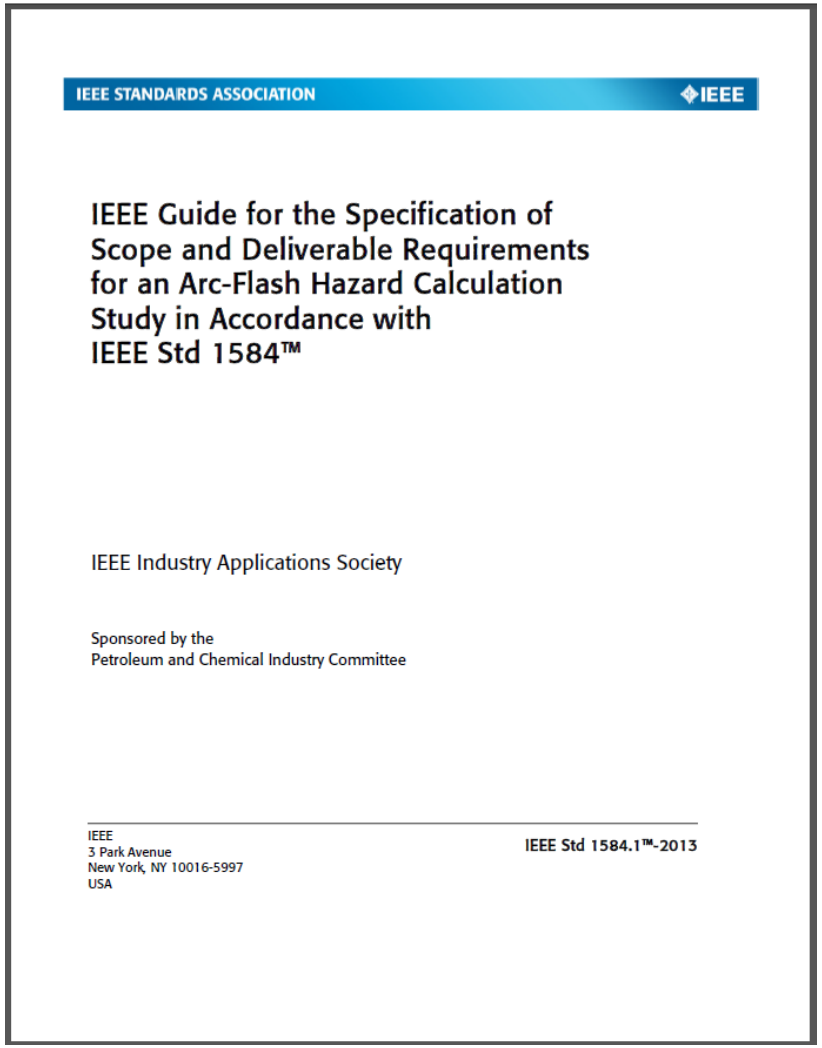

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IEEE Std 1584.1™-2013

IEEE-1584-20XX
Technical Information

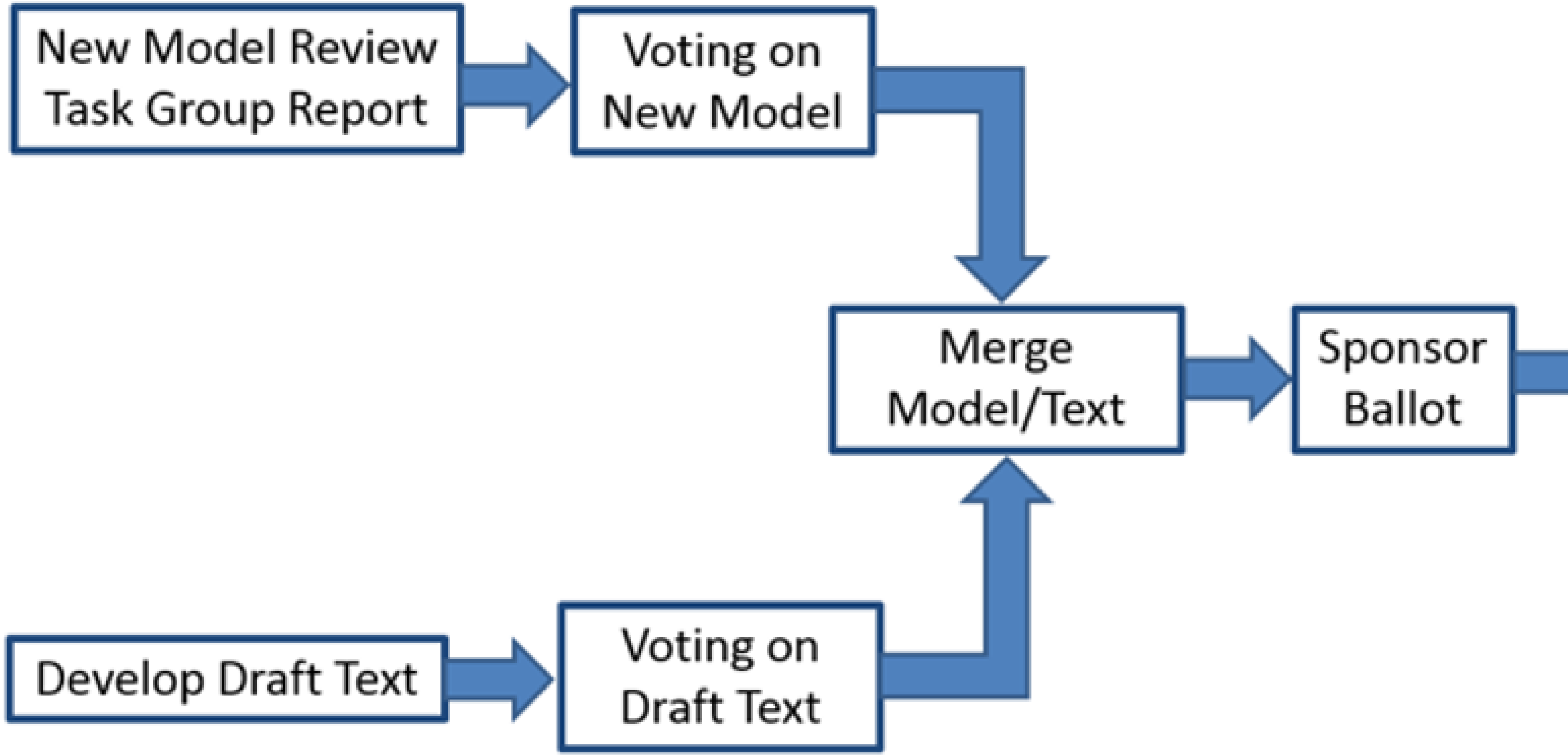
IEEE-1584.1-20XX
Deliverable Requirements

So What Does This Mean to Me?

- Design Engineers / Owners
  - Arc flash analysis per 1584.1
  - Engineers (PE?) to collect data
- Study Engineers
  - Consistency within your own group
  - Plan the data collection
- Manufacturers
  - Make data visible so we can collect it without taking energized equipment apart

Where Are We Now?

Two Paths



Moving Forward

Sponsor Ballot

- Standards Association sponsor ballot
  - Invited to comment
  - You elect to participate
  - Send the proposed standard for comments
- Ask questions
  - How to get consistent way of performing studies
    - Best practice guide in easy to read format
  - Provide specific guide for configuration types (VCB etc)
  - Provide examples with reasonable assumptions
- Get involved www.ieee.org/membership
  - Join the SA and vote during the sponsor ballot
    - IEEE member $54; non-member $248

Thank You

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