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# Arc Flash: What Is It and How Do We Design for It?

Thursday, 21 October 2021 | Technical Topic Webinar

**Presented By**

Alexandra Gregory | EIT Lecturer and Senior Electrical Engineer

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# Introduction - Presenter

*Alexandra Gregory*
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Senior Electrical Engineer
AECOM

- Chartered Professional Engineer (CPEng) with Engineers Australia
- Registered Professional Engineer (RPEQ) in QLD
- National Engineering Register (NER)

# Welcome & Introduction

# Agenda

| | |
|---|---|
| 1 | Welcome & Introduction |
| 2 | Arc Flash – What is it? |
| 3 | Arc flash – Causes & Consequences |
| 4 | Arch Flash – Designer Responsibilities |
| 5 | Conclusion and Q&A |

# Arc Flash – What is it?

*Q: What is the difference between Arc Flash and Arc Fault?*

**Arc faults** arise when current flows through the air between phase conductors or between phase conductors and neutral or ground.

**Arc Flash** comes from an earlier understanding that the burns from an arc fault were similar to the flash burns from a welding arc. That is, the heat was transferred to the individual by the radiant heat and light (infrared – ultraviolet) from the arc.

# Arc Flash – What is it?

What is it

- Arc occurs when gas between two conductors becomes ionised due to a potential voltage.
- Once ionised, gas becomes a conductor allowing current to flow
- The size of the arc is determined by the size of the power supply and the arc resistance  (gas, distance)
- Arc will sustain itself until it is quenched, suppressed or extinguished

# Arc Flash – What is it?

*Q: Is Arc flash what occurs during welding?*

- Welding / cutting activities are **controlled arcs** → These still pose risk to people and property
- Arc faults are **uncontrolled** and **unplanned**

# Arc flash – Causes & Consequences

- Most injury statistics are from the US, not Australia
- Often only fatalities and extreme cases are reported, with many any ‘lesser’ incidents going unnoticed
  - In November 2018, WorkCover Queensland reported that “Since 2013 there have been 32 incidents involving an arc flash. Of these, 20 resulted in injuries requiring hospitalization” (WorkCover Queensland, 2018).
  - January 2021 two workers suffered burns working on an LV switchboard that was reported by WorkSafe QLD

# Arc flash – Causes & Consequences

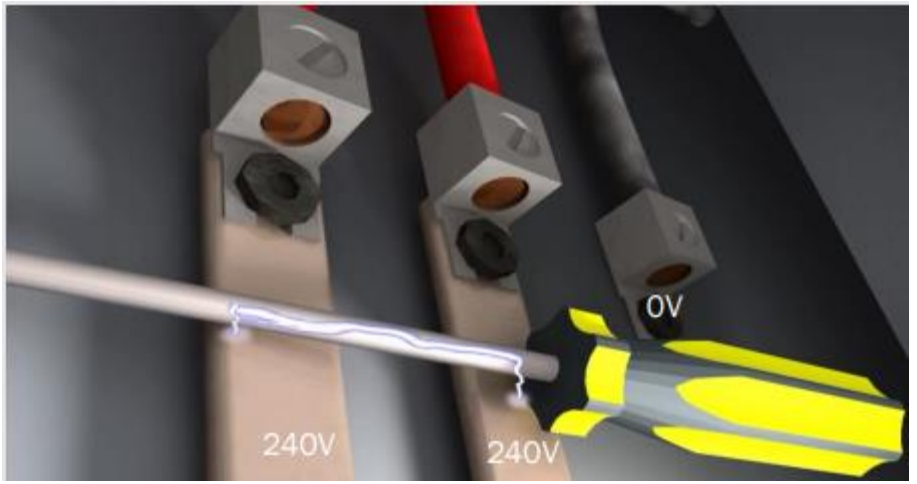
Causes

- Condensation (humidity in the switchgear assembly)
- Pollution in the form of foreign deposits (dust, salt) on busbars and parts of switchgear
- Entry of wildlife and their residue
- Transient over voltages following storm and/or switching surges
- Premature (unnoticed) ageing of insulating materials and protection devices following sporadic or thermal overload

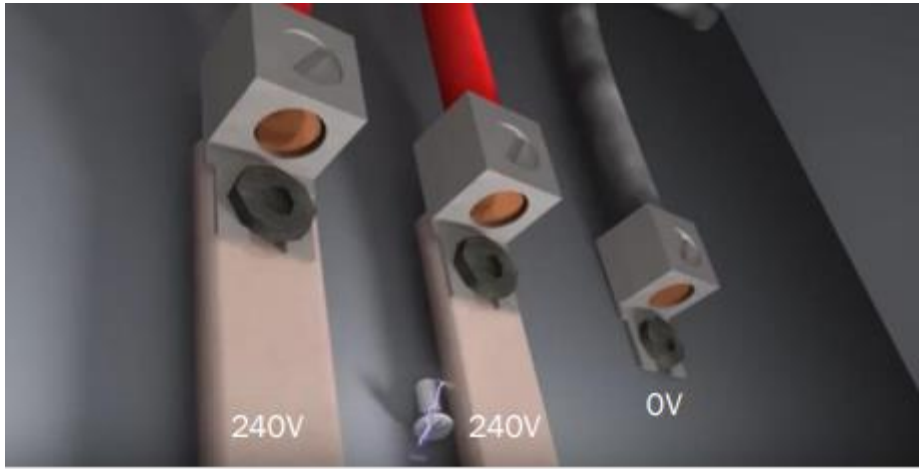
# Arc flash – Causes & Consequences

Causes cont.

- Failure during switchgear
- Loose or slack connections, defective contact points
- Working on or operating parts of the switchgear
- Dropped tools




Short Circuit fault

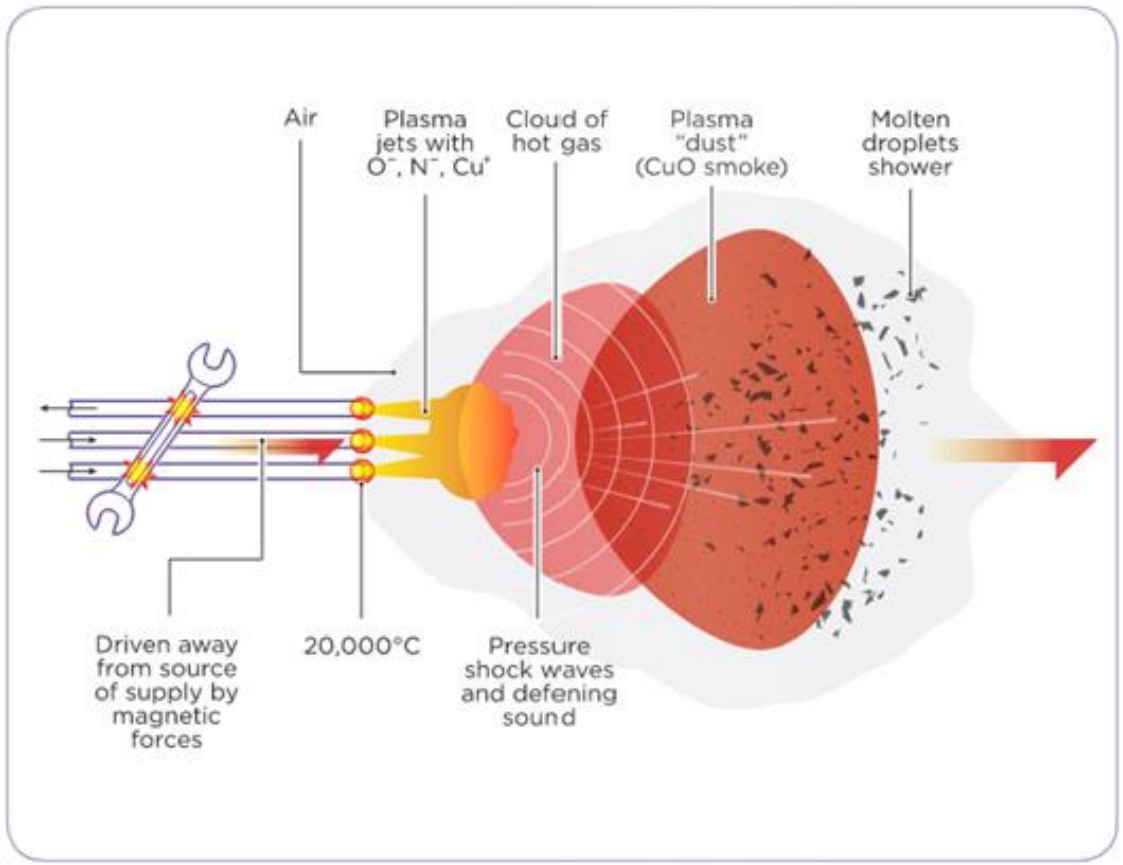



Phase to Ground Fault

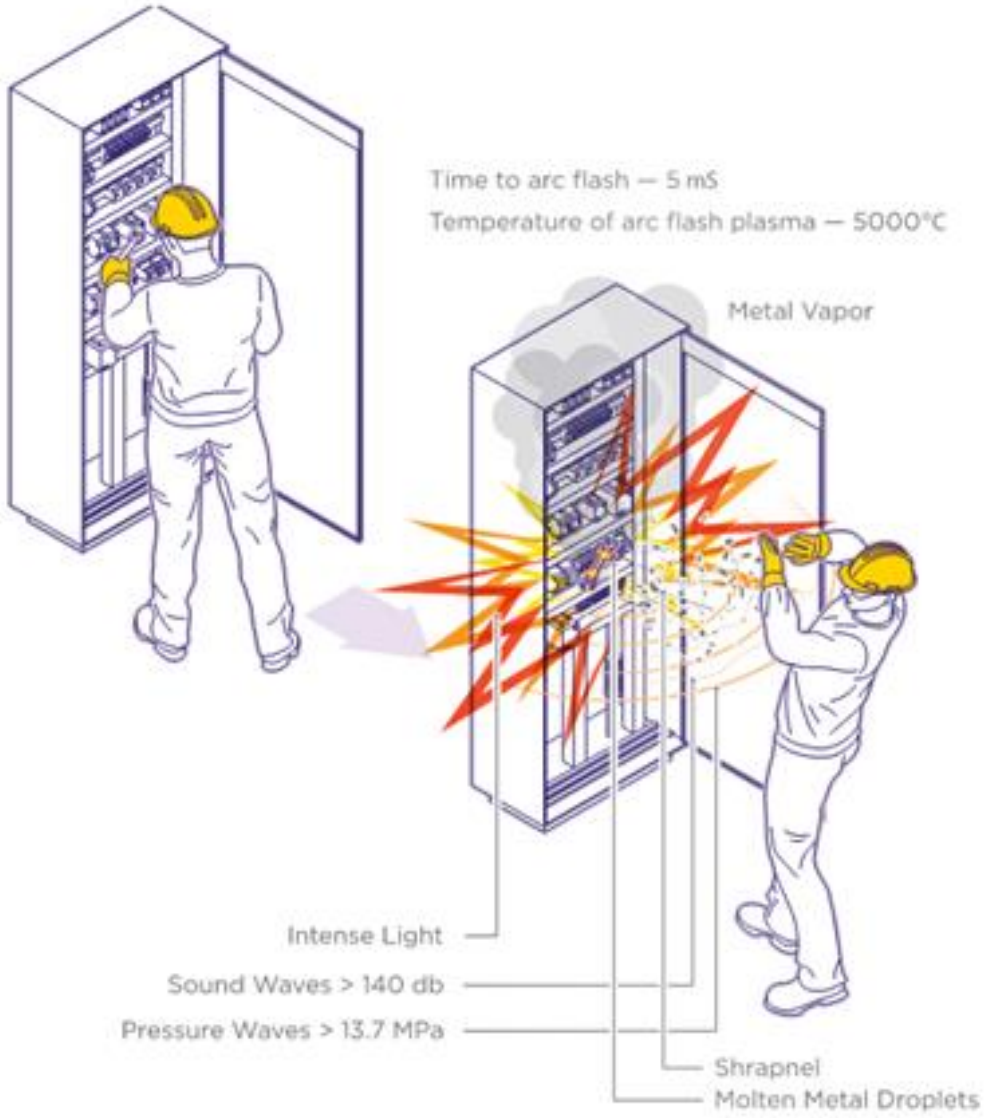
# Arc flash – Causes & Consequences

Result

- Plasma cloud - 5000 degree
- Arc temperatures - 20,000 deg
- Blinding light
- Deafening noise
- Explosive pressure wave
- Ejected molten metal
- Toxic smoke



# Arc flash – Causes & Consequences



# Arc flash – Causes & Consequences

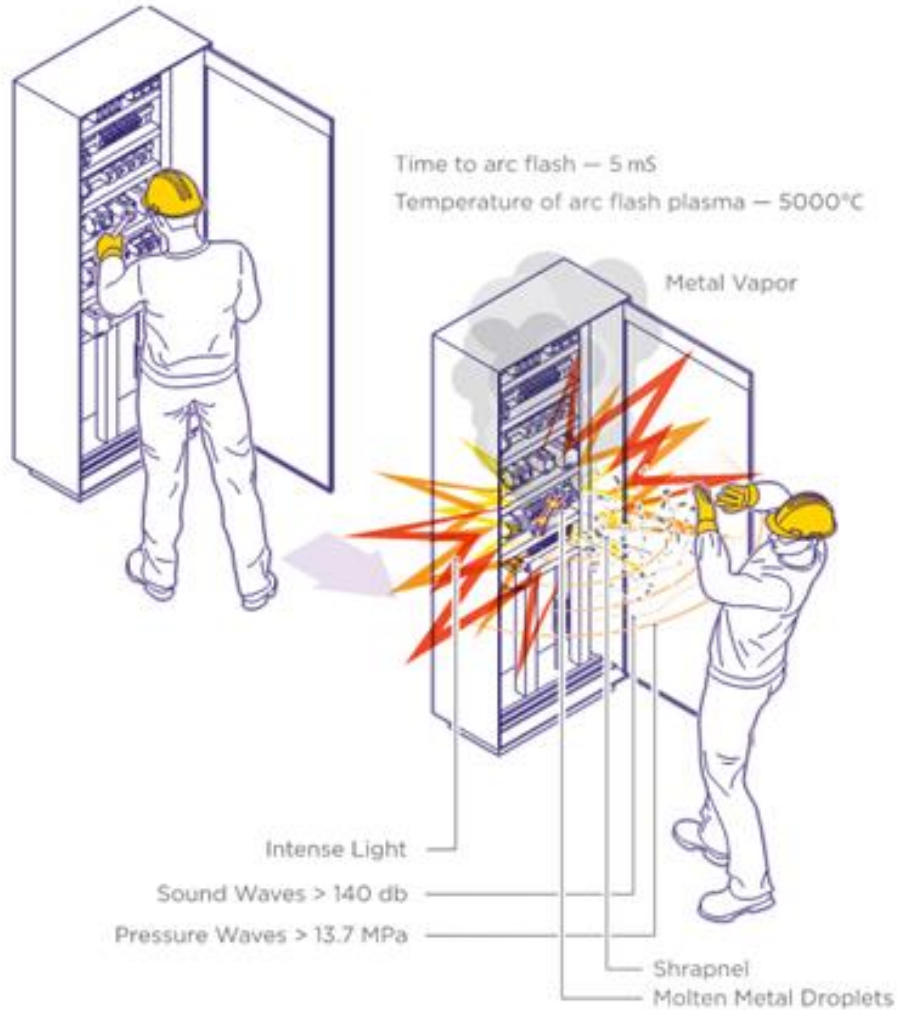
Consequences

- Damage to asset
- Disruption to operations
- Injury, permanent maiming or death of operators or bystanders

# Arc flash – Causes & Consequences

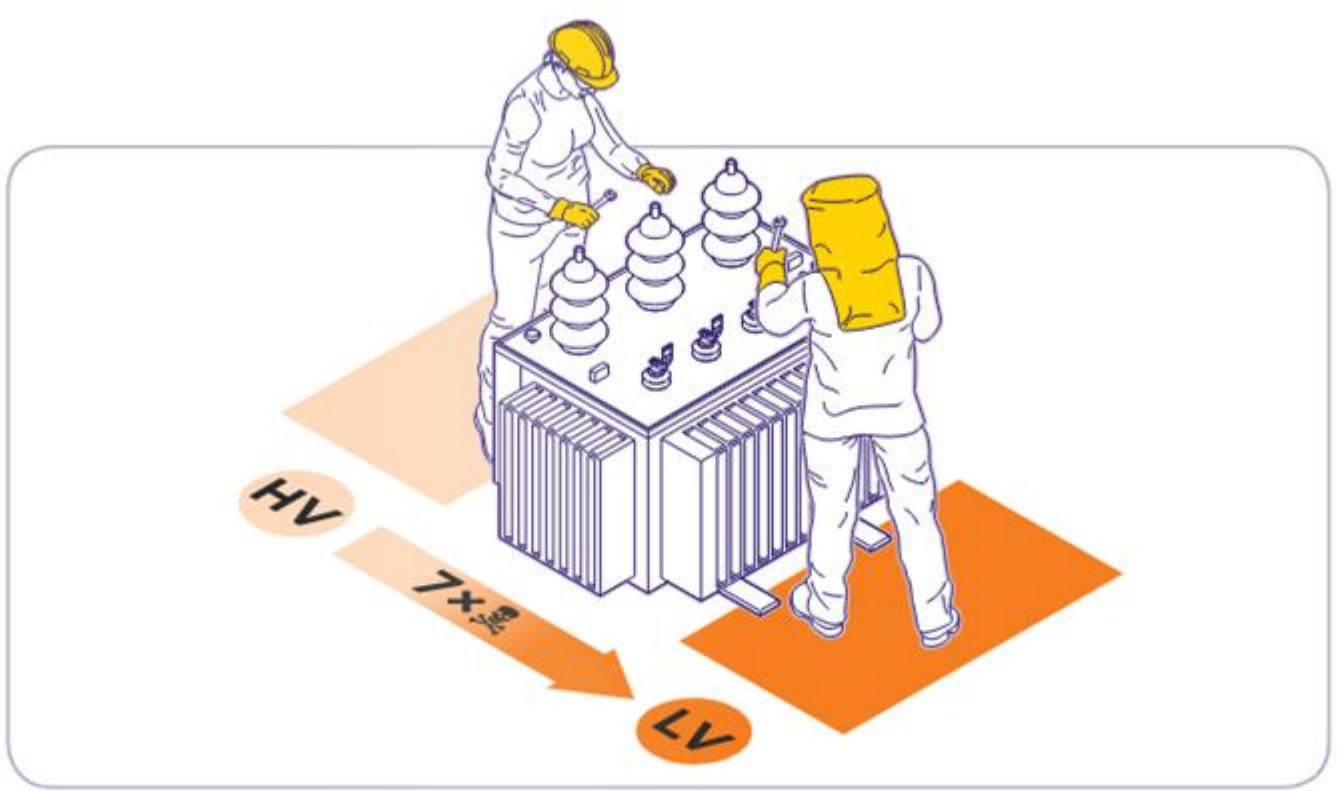
Consequences to Persons

- Plasma - Burns and ignition of clothing
- Light  - blindness and eye damage
- Noise - Can exceed that of a jet engine and damage hearing
- Gas/Fumes - May be toxic
- Blast - Causes flying debris



# Arc flash – Causes & Consequences

*Q: Would High Voltage or Low voltage Arc Flash incident be more dangerous to personnel?*




LOW VOLTAGE!

# Arc flash – Causes & Consequences

## Characteristics of a High voltage fault:

- Low impedance
- Faster clearing time
- Larger working distance between conductors

## Characteristics of a Low voltage  fault:

- Higher fault impedance, slower clearing time
- Closer proximity of conductors
- Lack of procedures
- Worker complacency

# Arc flash – Designer Responsibilities

→ No standards relating specifically to Arc flash are legislated

→But we DO have a Duty of Care

Clause 19 of the Queensland Work Health and Safety Act 2011(5) (WHSA) states that *a person conducting a business or undertaking (PCBU) must ensure as far as is reasonably practicable, the health and safety of workers and others at the workplace, as far as is reasonably practicable*

# Arc flash – Designer Responsibilities

## Common Standards

- *NFPA 70E – North American Version of AS/NZS 3000*
- *IEEE 1584 "Guide for Performing Arc Flash Hazard Calculations“*

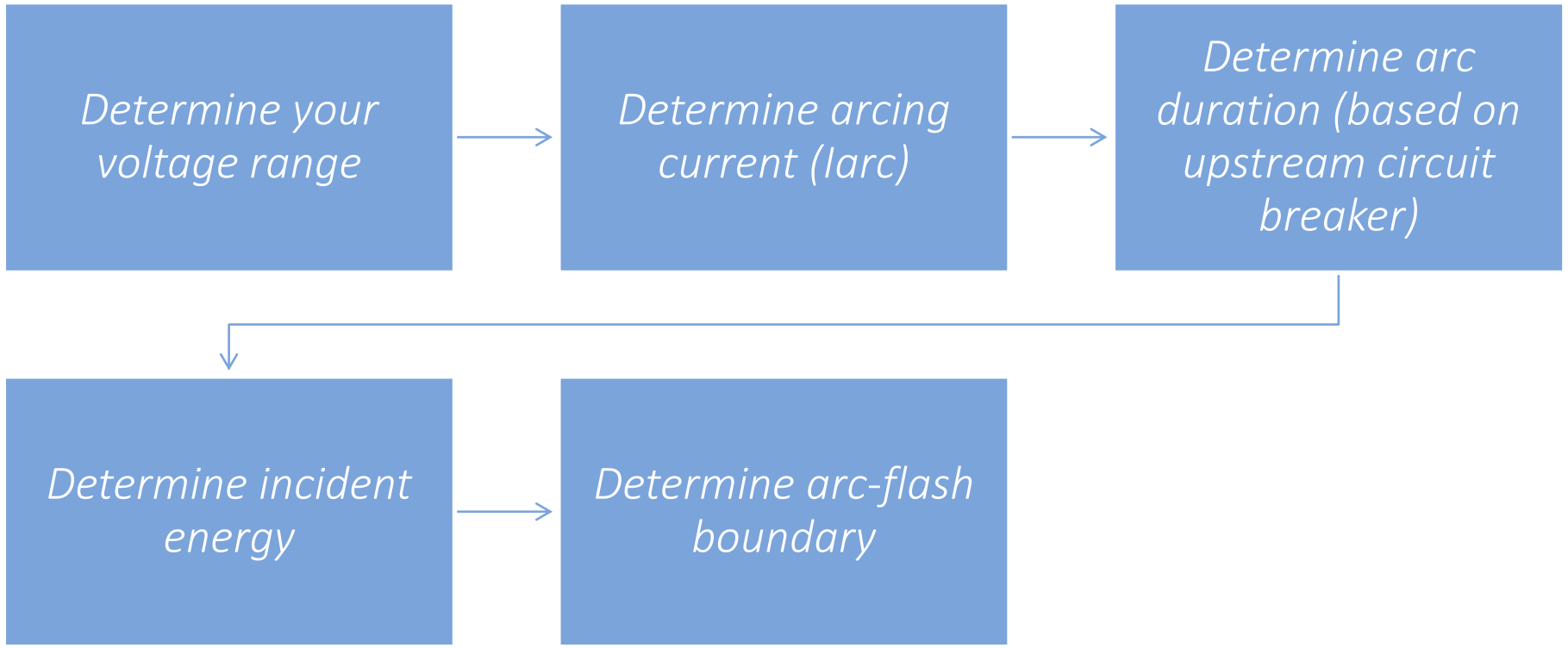
Neither are legislated in Australia – but have become the “defacto” arc flash standards for Australia

**IEEE 1584** → Used to determine Arc Flash incident Energy & Arc Flash Boundary

**NFPA 70E** → • Uses Incident Energy Levels to determine PPE Requirements

# Arc flash – Designer Responsibilities

## How to perform Arc Flash Calculations



# Arc flash – Designer Responsibilities

**Arc Flash Incident Energy** - The amount of thermal energy a surface (or person) is exposed to at a set distance from an arc, typically called the working distance (cal/cm2)

**Arc Flash Boundary** - This is the approach limit at which a person would be expected to receive a curable burn on exposed skin

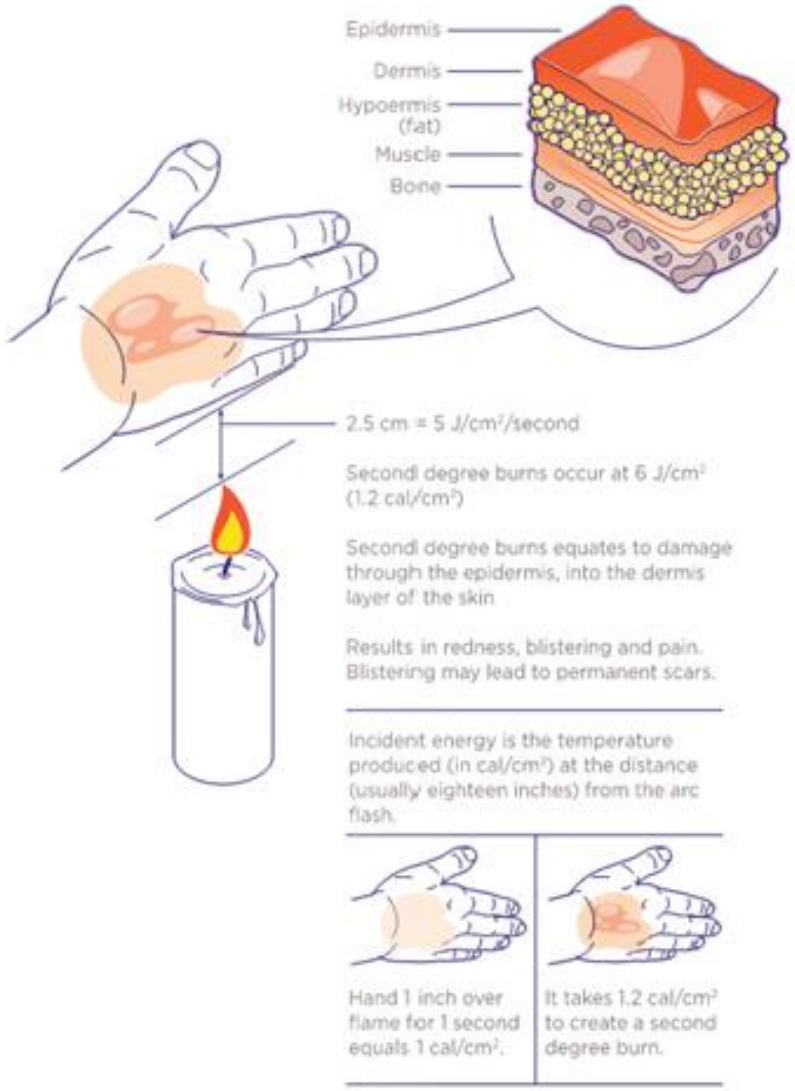
*"Working Distance"/ "Safe Boundary" defined by IEEE 1584 as < 1.2 cal/cm2*

*What does this look like?*

# Arc flash – Designer Responsibilities

What does 1.2 cal/cm2 look like?

- Second degree burns
- Fully recoverable – 'survivable'
- Does this satisfy our Duty of Care?



# Arc flash – Designer Responsibilities

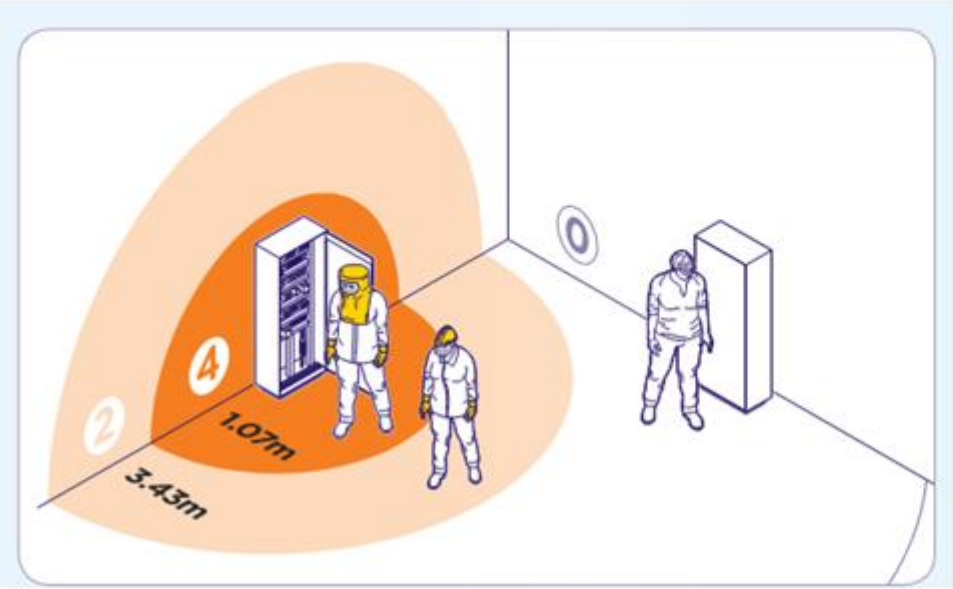
*Calculations are done.. Now what?*

Incident Energy determines PPE Categories

| PPE CATEGORY 1 | PPE CATEGORY 2 | PPE CATEGORY 3 | PPE CATEGORY 4 |
|---|---|---|---|
| Minimum Arc Rating of<br>**4 cal/cm²** | Minimum Arc Rating of<br>**8 cal/cm²** | Minimum Arc Rating of<br>**25 cal/cm²** | Minimum Arc Rating of<br>**40 cal/cm²** |
| **Arc Rated Clothing:**<br>• AR long-sleeve shirt and pants, or AR coverall<br>• AR face shield, or AR flash suit hood<br>• AR jacket, parka, rainwear, or hard hat liner (as needed) | **Arc Rated Clothing:**<br>• AR long-sleeve shirt and pants, or AR coverall<br>• AR flash suit hood, or AR face shield and AR balaclava<br>• AR jacket, parka, rainwear, or hard hat liner (as needed) | **Arc Rated Clothing:**<br>• As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants<br>• AR flash suit hood<br>• AR gloves<br>• AR jacket, parka, rainwear, or hard hat liner (as needed) | **Arc Rated Clothing:**<br>• As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants<br>• AR flash suit hood<br>• AR gloves<br>• AR jacket, parka, rainwear, or hard hat liner (as needed) |
| **Protective Equipment:**<br>• Hard hat<br>• Safety glasses or safety goggles<br>• Hearing protection (with inserts)<br>• Heavy-duty leather gloves<br>• Leather footwear (as needed) | **Protective Equipment:**<br>• Hard hat<br>• Safety glasses or safety goggles<br>• Hearing protection (with inserts)<br>• Heavy-duty leather gloves<br>• Leather footwear | **Protective Equipment:**<br>• Hard hat<br>• Safety glasses or safety goggles<br>• Hearing protection (with inserts)<br>• Leather footwear (as needed) | **Protective Equipment:**<br>• Hard hat<br>• Safety glasses or safety goggles<br>• Hearing protection (with inserts)<br>• Leather footwear (as needed) |

# Arc flash – Designer Responsibilities

## Arc Flash boundaries in practice

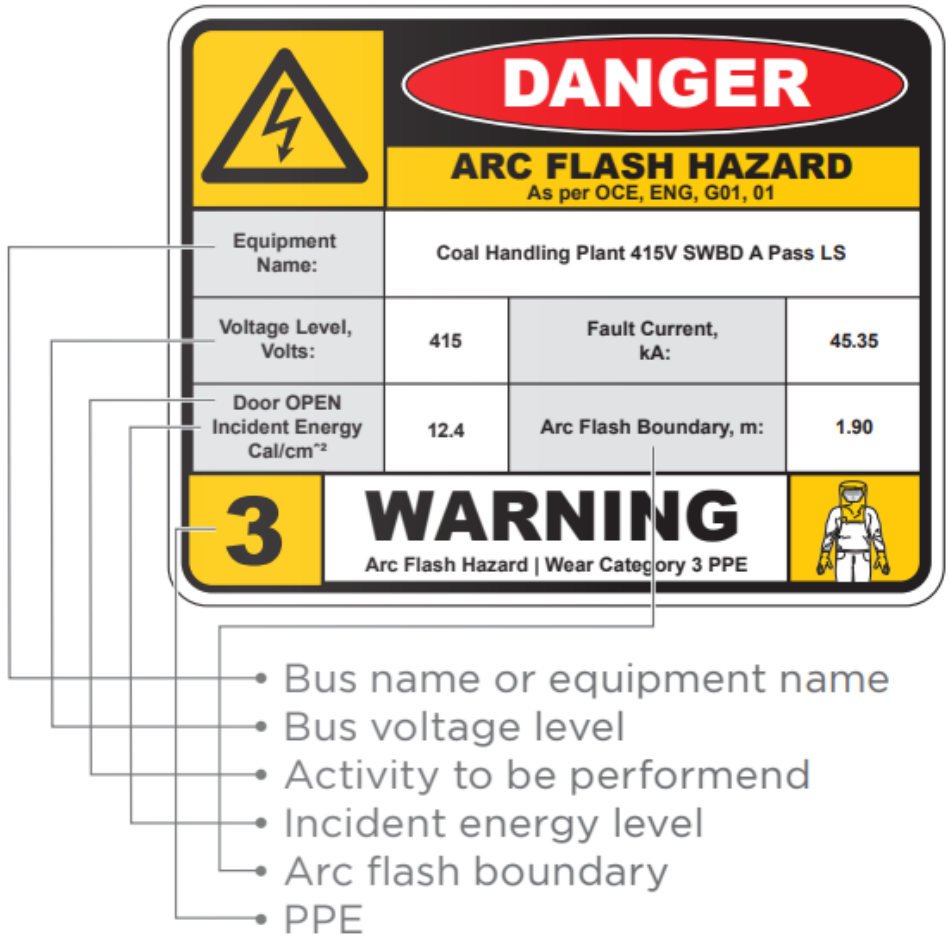




# Arc flash – Designer Responsibilities

## Arc Flash Hazard Labels

- Becoming more frequent in project
- Include information such as
  - Equipment name
  - Bus voltage level
  - Activity to be performed
  - Arc Flash boundary
  - PPE level required
- No set layout
- Not mandated

Label example



# Arc flash – Designer Responsibilities

General Mitigation strategies

1. Eliminate the Risk – De-energised equipment
2. Complete an Arc flash study to determine safe working boundaries and PPE
    1. Inform workers of the risk of the risks
    2. Put up Arc flash labels on switchboard(s) with PPE requirements
3. Switchboards
    1. Arc fault contained switchboard(s)
    2. Arc fault Detection: Design equipment to reduce incident energy

# Conclusion/summary

- Arc Flash is an uncontrolled event associated with live electrical work that has serious consequences to personnel and equipment
- Designers, Workers, facility owners are obligated to mitigate this risk
- Risks can be mitigated in design (elimination and substitution), with the second line of defense being PPE (administrative controls)
- Arc Flash studies expecting to become the new ‘norm’ and more onerous – not accepting of 1.2 cal/m2
- Watch this space !

# Reference list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# Q&A

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