



ARC FLASH MANAGEMENT

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Purpose

This Standard sets out the minimum requirements for Arc Flash Management within Contact Energy and establishes a policy for the evaluation of arc flash hazards. This Guide describes the recommended levels of Personal Protective Equipment (PPE) to be worn to provide adequate control measures when operating HV and/or LV Apparatus that has not been fully isolated or where shutters on live circuits have not been locked and cautioned in the closed position.

Scope

This Standard applies to all Generating Sites

Exclusions:

Nil

Deviations:

Deviations from the requirements of this Standard can be considered where full compliance is not appropriate. Circumstances which require deviation from this Standard may include regulatory obligations, local conditions or other circumstances which make it infeasible or inappropriate for a particular site or set of circumstances.

In order to authorise any deviation from this Standard:

- The impact and duration of the deviation **MUST** be risk assessed and documented. Where appropriate the Risk Register **MUST** be updated to reflect the Deviation

Agreement to the deviation **MUST** be obtained from the Corporate Engineering Authority and Approval obtained from the Group Generation Manager.

Definitions

Arc-flash hazard: A dangerous condition associated with the possible release of energy caused by an electric arc.

Arc Flash protection boundary: An approach limit at a distance from live parts that are uninsulated or exposed within which a person could receive a second-degree burn. This boundary is the closest anyone may approach without the use of PPE. The available short circuit current predicted fault duration and the voltage are all needed to determine the flash protection boundary. This boundary is the distance from the arc source where there is an incident energy level of 1.2 cal/cm² (5.0 J/cm²). There are many ways in which this boundary can be calculated:

- Analysis based on Article 130.3 (A)
- Analysis based on NFPA 70E Annex D
- Analysis based on IEEE 1584-2002
- Analysis based on IEEE 1584-2018

Enclosed electrical equipment, as compared with an arc in open air. An arc-flash inside of a box will achieve a higher incident energy than an arc-flash in open air. This is because the sides of the box will focus the arc-flash energy towards the opening, whereas open air will allow the energy to dissipate in all directions. Within Contact Energy the Arc Flash protection boundary is regarded as the entire switch room and the boundary may be crossed only by a qualified person, or an “unqualified” person, wearing appropriate personal protective clothing and who is accompanied by a “qualified” person.

Boundaries: The limited, restricted, and prohibited approach boundaries are determined using NFPA Table 130.2 (C) Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection.

Electrical hazard: A dangerous condition in which inadvertent or unintentional contact or equipment failure can result in shock, arc-flash burn, thermal burn, or blast.

Fault hazard analysis: A method to determine the risk of personal injury as a result of exposure to incident energy from an electrical arc flash.

Incident energy: Is measured in joules per centimetre squared (in J/cm^2) or in calories per centimetre squared (cal/cm^2). This is the energy per unit area on a surface, located a certain distance from the potential arc source, generated during an electric arc event. Second degree burns occur at an energy level of approximately $1.2 cal/cm^2$. NFPA 70E Article 130.3(C) requires label to display this information. Annex D.7.5

Limited Approach Boundary: This boundary may be crossed only by a qualified person, wearing appropriate personal protective clothing. Documented training for the hazards of the equipment being serviced, as well as general training on the hazards of working on energized equipment, are required to become “qualified.” Proper application of PPE **MUST** be a part of this training. (NFPA 70E Annex C.1.1 and C.1.2.2). The Limited Approach Boundary is identified on Arc Flash warning signs.

Required Outcomes

In NZ, an arc flash with high incident energy will normally be classified as a significant hazard under the Health and Safety in Employment Act due to the potential for serious harm. Arc flash may also be considered a significant hazard to the public and therefore would need to be managed under the Safety Management Systems required under the Electricity Act for the Electricity Supply Industry.

Sites **MUST** conduct an assessment to determine potential exposure to an electric arc for employees and contractors who work on or near energised parts, equipment or lines in accordance with the EEA Arc Flash guide. The site **MUST** take all reasonably practicable steps to either;

- Eliminate the exposure,
- If elimination is not practicable, isolate the exposure from employees, or
- If elimination or isolation is not practicable, minimize the energy exposure to an acceptable level (Low Risk Exposure), and ensure protective clothing and equipment is available to employees as required.

Preferred means of achieving a reduction in exposure energy includes:

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STANDARD



- Faster protection operation under arc fault conditions through revised protection settings,
- Retrofitted engineered modifications to equipment, i.e., fast acting arc flash detection systems, directional arc chutes for venting etc.
- Increased operational working distance from the equipment,
- Establishing limited approach boundaries for persons not working on or near the equipment.

Where minimization of exposure energy is the selected course of action, reduction to below 8 cal/cm² is regarded as an acceptable level in terms of risk exposure.

Contact Energy define arc flash risk exposure as follow:

High Risk Exposure - Arc Flash Incident energy above 25 cal/cm² (Cat 4)

Medium Risk Exposure - Arc Flash Incident energy between 8 and 25 cal/cm² (Cat 3)

Low Risk Exposure - Arc Flash Incident energy below 8 cal/cm² (Cat 0, 1 & 2)

Standard Contact Energy FR (Flame Retardant) overalls have a capacity to withstand incident energies up to 8 cal/cm². These overalls together with, safety glasses, steel cap footwear and eye protection as the standard PPE requirements for entering electrical switch rooms. Minimum PPE requirements to enter a switch room is the main driver for regarding exposure to incident energy below 8 cal/cm² as low risk.

Statutory Requirements or Constraints

All activities **MUST** be conducted in compliance with relevant legislation or other constraints such as Policies or recognised Codes of Practice. This legislation/constraints include but are not limited to the following:

- Health and Safety at Work Act 2015 Electricity Act for the Electricity Supply Industry
- EEA Arc Flash Guide

Standard

1.1. SWITCHGEAR OPERATIONS

Only personnel who have been trained and authorised to operate switchgear **MUST** be allowed to rack circuit breakers in and out of the service position and conduct local switching operations.

Wherever possible, switching operations **MUST** be conducted remotely.

All non-authorised staff **MUST** be removed from the operational area prior to conducting local operations.

Prior to conducting local switching operations the Authorised Person **MUST** check that the mechanical protection offered by the switchgear is in place, i.e., all bolts and screws in the front panel are present and secured. Where switching operations require the Authorised Person to have the cubicle door open for specific operations (e.g., racking circuit breakers in and out of the service position) the time at risk **MUST** be minimised. Once the circuit breaker has been racked in or out from its service position then the door **MUST** be secured to provide protection.

1.2. HAZARD/RISK ASSESSMENT

All tasks **MUST** be risk assessed and this includes operational practices on electrical switchgear.

The primary requirement **MUST** be to create safe working conditions and where possible this **MUST** be achieved by isolation of LV and HV Apparatus with the additional precaution of earthing of HV Apparatus. Where isolation and/or earthing is not reasonably practicable, then any residual risks should be assessed, and appropriate control measures implemented.

Operational procedures that may have to be carried out with plant in service include; local switching, racking circuit breakers in or out of the service position and earthing through fixed earthing devices.

The risk assessment **MUST** be conducted by a suitably qualified and experienced person who is fully competent with the switchgear on site and is capable of calculating the heat flux created in the event of an electrical fault occurring on the Apparatus. If the equipment has not yet been labelled or is being dismantled in such a way that the normal level of protection has changed a specialised person report may also be required.

EQUIPMENT DESIGN

As with all hazards, equipment design is fundamental to preventing or mitigating an arc flash risk. As new equipment can be purchased to meet arc flash containment criteria, the

purchaser should specify these criteria and ensure they are commissioned. New switchboards **MUST** be designed, and type tested to IEC 62271-200:2021 and new switch rooms **MUST** be installed in accordance with all manufacturer's recommendations/guidelines: including spacing and arc flash venting requirements.

These requirements **MUST** be met during the civil/structural design phase, and particular note should be made of the location of venting in relation to switchgear walls and surroundings.

Relevant Standards which include equipment design for arc flash hazard mitigation include but are not limited to;

- IEC 62271:2022 (Series) *High-voltage switchgear and control gear – All Parts*
- IEC 60947:2021 (Series) *Low-voltage switchgear and control gear – All Parts*
- IEC TR 61641:2014 *Enclosed low-voltage switchgear and control gear assemblies – Guide for testing under conditions of arcing due to internal fault*
- AS/NZS IEC 61439:2016 (Series) *Low-voltage switchgear and control gear assemblies – All Parts*

When ordering new equipment, the purchaser is to specify relevant environmental conditions in which the equipment will operate, including.

- Whether the public will have access to the immediate proximity of the equipment.
- Maximum fault levels,
- Environmental conditions, e.g., geothermal environment, airborne contaminants etc.

Switchgear designs which enable racking operations to be performed with doors closed may allow the arc flash rating of the switchboard to remain applicable during these periods.

Existing equipment can be retrofitted with appropriate technologies to mitigate risk. The following improvements should be considered.

- Reducing arc current
- Faster fault clearance
- Additional fault detection, e.g., optical
- Replacing equipment with modern equipment designed to eliminate or minimise arc flash hazards.
- Fit systems to contain or vent arc flash.

1.3. LABELLING OF EQUIPMENT.

For equipment such as circuit breakers, transformers, and equipment in switchyards, with an identified residual hazard and additional PPE requirement, a label **MUST** be applied to the equipment or at the equipment access point to give the relevant information. Information to include approach distances permitted.

An equipment label should be of an easily readable size and should include.

- A 'warning' statement
- Description of hazard, e.g., 'arc flash hazard'
- Incident energy at specified working distance, e.g., 10 cal/cm² at 600mm, or rating of PPE to be used at that site/equipment.

Examples of standardised warning signs available in Appendix A

1.4. ESTABLISHING PROTECTION BOUNDARIES

Within stations, switchyards, switch room and other enclosed locations where employees/contractors regularly work, an arc flash protection boundary **MUST** be established where practicable for each equipment installation, or specific type of work, which could generate an arc flash.

The arc flash protection boundary is at the distance from the arc at which the bare skin temperature would not exceed 80°C (This corresponds to an incident energy of <1.2 cal/cm² for 0.1s or more, or 1.5 cal/cm² for <0.1s). Any work or entry within the arc flash protection boundary requires the use of appropriate PPE.

1.5. SELECTION OF CLOTHING AND PPE

Outer Wear

If the exposure to an arc flash would not exceed 2 cal/cm² then full body cover is required but the outer wear is not required to be arc flash or fire retardant rated. It **MUST**, however, be at least 185gsm and 100% cotton, or have equivalent performance characteristics. The standard issue Contact overalls is all that is required.

If the exposure to an arc flash would exceed 1.2 cal/cm² then arc flash rated outer wear is required, with the rating being dependent on the incident energy exposure as calculated in the hazard assessment. Contact FR overalls are rated up to 8 cal/cm².

Employees **MUST** be advised that any clothing between the outer wear and the skin (undergarments) should be natural fibre or of a suitable flame-retardant material, and not synthetic, including shirts, trousers etc. Synthetic undergarments may create more severe injuries in an arc flash event.

While elastic bands or similar may be necessary, they should be minimized or covered so that they do not produce molten or flaming debris.

If undergarments of flame-retardant material are considered, suppliers should be asked for assurances that the material will not be harmful to the skin from chemicals used.

Undergarments should be firm fitting.

1.6. Clothing Layering

Layering of arc flash rated clothing is recommended for effectiveness, comfort, and flexibility. The net rating of the layers is generally greater than the sum of the rating of individual layers, but as there are no clear guidelines for determining this benefit, only the rating of the layers **MUST** be added to determine the overall protection. Where there is documented evidence that the effectiveness of layers is greater than the sum of the individual layers that evidence may be used.

PPE

Selection of PPE **MUST** consider all exposed parts of the body, and may include gloves, face/eye protection, footwear etc.

Where the exposure to an arc flash requires clothing of 8 cal/cm² or greater, specifically rated PPE in addition to clothing **MUST** be worn, including a suitably rated thermal face shield.

Note:

- PPE is to be rated to suit the assessed exposure.
- Excessive PPE should be avoided as it may limit the employee's movements.

Contact Energy only permits live work on any conductors above 1kV if task specific approved procedures and competency are applied. Live work at voltages below 1kV are subject to the EEA LV Electrical Guide. **The PPE requirements for general LV work is total body covering and safety glasses, however this is subject to review.**

1.7. INITIAL ACTIONS

Should an assessment and subsequent engineering controls not be able to be actioned or completed in the short term, and if the hazard is significant, the following actions should be considered.

- Employees to be issued with a minimum of 8 cal/cm² outer wear.
- Employees should be advised not to wear synthetic under garments.
- Employees to wear 8 cal/cm² FR overalls issued clothing when entering switch rooms or approach elevated risk arc flash areas.
- Employee distance from equipment to be maximized.
- Safety glasses to be worn.
- Training provided detailing risks and controls.

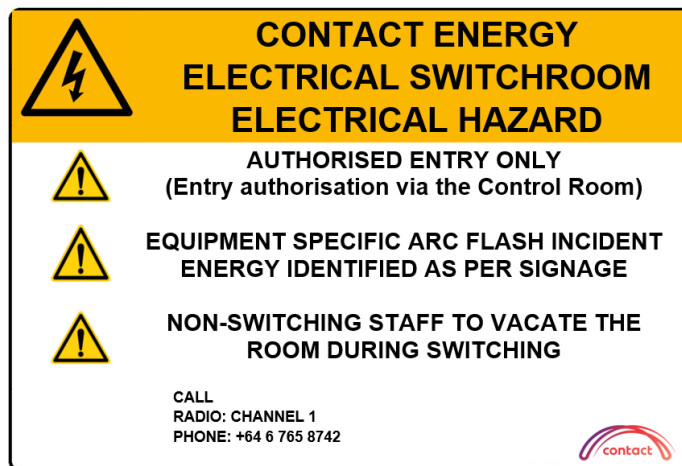
Performance Measures

Where possible the Standard should include information about how performance against the requirements of the Standard should be measured. For example, a Standard which includes requirements for protective devices could require KPI's on the number of protective devices which have exceeded their planned maintenance interval, number of occasions where the devices have operated (both as genuine protection and spurious operation)

Related Documents

- EEA Arc Flash Guide
- Protect @ Contact Essentials, Arc Flash DMS 10000023837

Appendix A



WARNING

3.3 kV Gas Compressor Switch Room
Arc Flash and Shock Hazard
Appropriate PPE Required

System Voltage	3300 V
Fault Current	20.6 kA
Arcing Current	16.7 kA
Arc Flash Incident Energy	6.2 cal/cm ² @ 910mm working Distance
Arc Flash Hazard Category	2
CAT 2 Arc Flash Protection Boundary	0.67 m

PPE: General Access:

- Cat 2 Arc-Flash Overalls (min 8 cal/cm²)
- Hard hat
- Safety glasses
- Safety Footwear
- Gloves


Live LV work and HV work in the vicinity of exposed conductors requires specific procedures and approval.

Additional PPE Required: For local switching, racking & earthing of CBs:


- Switching gloves & hearing protection
- Cat 2 switching helmet and face shield

PPE Requirements for access to switch room

Largest 'Limited Approach Boundary' inside switch room, around any associated switchgear, increased PPE



The above signs **MUST** be placed on all switch room doors.



WARNING

BOP 400V MCC Switchboard (Bus A)
Arc Flash and Shock Hazard
Appropriate PPE Required

System Voltage	400 V	Fault Current	33.4 kA
Arc Flash Incident Energy	6.8 cal/cm ²	Arcing Current	15.4 kA
Arc Flash Hazard Category	2	@ Working Distance	610 mm
Cat 0 Arc Flash Protection Boundary	1.98 m		
Cat 2 Arc Flash Protection Boundary	0.55 m		

PPE: General Visual Inspection:

- Cat 2 Arc-Flash Overalls (min 8 cal/cm²)
- Hard hat
- Safety glasses
- Safety Footwear
- Gloves

Additional PPE Required: For local switching & racking of CBs or removing switchboard covers/cells:

- Switching gloves
- Cat 2 helmet & face shield

