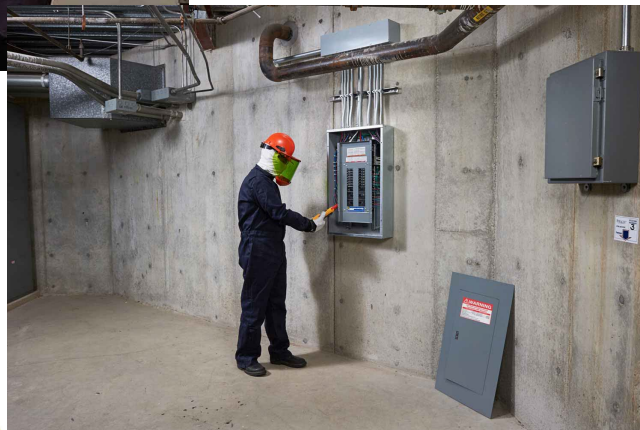


Arc Flash Procedure

WNH Q39- Revision 1.0

Effective from August 2024



Revision History

Rev	Reason for Revision	Date	Prepared	Reviewed	Approved
1	Initial Release	August 2024	Alistair Mason	Chris Sims	Jie Yao

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1.0 This Document

1.1 Purpose

The purpose of this procedure is to reduce the likelihood of arc flash occurring and eliminate the risk of injury resulting from arc flash should it occur. Correct use of the procedure will ensure that adequate controls are in place before carrying out any electrical work that has the potential for arc flash to occur.

1.2 Scope

This procedure applies on all Woolnorth Renewables (WNR) worksites and shall be used when any work is to be carried out on electrical equipment that has been identified to have the potential to cause arc flash.

1.3 Review Period

This procedure, site labelling and arc flash ratings are to be reviewed every 5 years or when major changes occur to the installations that affect the arc flash hazards.

2.0 Arc Flash

An arc flash and arc blast are a release of electrical energy that leaves its intended path and travels through the air from one conductor to another, or to ground. An arc flash can happen in a split-second, causing serious burns, injury, and death as well as damage to property and equipment.

An arc flash usually occurs in large switchboards but can also occur in smaller switchboards, electricity supply pillars or large electrical equipment.

Common causes of arc flash include:

- unsafe work practices and procedures
- foreign materials
- breakdown of busbar insulation
- electrical equipment failure such as a switch, circuit breaker or loose cables
- contacting energised equipment with uninsulated tools
- using test equipment not designed or rated for the job.

2.1 Identify the Hazards

When a technician is required to work on electrical equipment, all reasonably practicable measures should be taken to protect themselves from the harmful effects of electric arc flash hazards through hazard elimination and risk reduction.

To achieve this the following steps should be undertaken:

- A. Understand the hazard.
- B. Identify assets or asset groups with arc flash hazard potential.
- C. Quantify the hazard (calculate the arc flash incident energy on each asset or asset group)
- D. Assess the risk.
- E. Develop and implement risk treatments using the hierarchy of controls.
- F. Validate control effectiveness.

Unintended and uncontrolled electrical arc faults may occur on several pieces of electrical equipment (electrical systems), under different circumstances, and during a range of activities. Any activity in the vicinity of energized conductors has the potential for arc flash, but arc flash most commonly occurs when a person is working on an energised circuit or equipment (knowing it is energised or believing it is not).

2.2 Assessing the Risks

The arc flash risk increases by the degree of interaction with the energised equipment. The amount of energy that strikes an individual during an arc fault is termed **incident energy** and is usually measured in Joules/cm² (or calories/cm²). In general, the higher the fault current and/or the longer the protection clearing time, and/or and the shorter the distance from the arc, the greater the incident energy.

Second-degree burns (also called 'Partial Thickness Burns') are possible on unprotected skin from exposure to arc fault incident energies. The onset of a second-degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm² (5 J/cm²) for one second. Therefore, 5 J/cm² (1.2 cal/cm²) is an important incident energy level threshold for arc fault hazard management.

An independent comprehensive arc flash study has been completed by C5 Pro Solutions for WNR across all three sites electrical systems. The scope of the associated reports (BPWF, SBWF, MRWF) covers short-circuit fault levels and worst-case arc flash incident energy and boundary calculations. These studies were performed on wind farm associated switchboards within wind turbines and the main 22 kV switchboard.

The arc flash study results presented several areas and circumstances around the sites where arcing faults are generally more hazardous:

- 22 kV switchboards (main switchboard and turbine RMU's)
- LV Switchboards
- 415 V Automatic Transfer Switch (ATS)
- Battery Banks (Terminals)
- Nacelle Switchboards
- Control Cabinets – Base of Tower

The risk assessment produced PPE control requirements as outlined in Section 3 of the Procedure.

2.3 Controlling the Risks

The greatest likelihood of causing an arc flash will generally be during the restoration of equipment following a fault or when equipment may have a defect, or following maintenance activities that require physical disconnection and reconnection.

Under these circumstances the appropriate PPE as outlined below (Section 3) shall be worn to further mitigate the arc flash hazard.

Wherever practicable, switching should be conducted from outside the arc flash boundary or from a distance at which the arc flash incident energy will be less than the Category 2 PPE being worn by the operator. The second worker shall always remain well clear of the Arc Flash zone so that both members of the work party are not exposed to the same risk.

2.4 Arc Flash Control Measures

Controls for arc flash typically rely to the following principles:

- Reduction of arc flash energy
- Reduce exposure of personnel to the arc flash
- Protect people from the arc flash through the application of the Hierarchy of Controls
- Increase the commitment to experience, skills and capabilities of relevant workers.

Elimination is the most effective risk control/ mitigation method. The elimination of arc flash risk requires that there is no exposure of personnel to energised electrical equipment, either by the physical separation from the energised equipment, or by the effective isolation (and earthed if high voltage) and proof that electrical conductors are deenergised.

Whilst the isolation and earthing of conductors eliminates the risk, the process to isolate, prove deenergised and earth conductors still has arc flash risk.

With arc flash, where the hazard cannot be eliminated, a combination of control measures should be used to mitigate the hazard.

- Eliminate the need to be near energised electrical conductors – relocate the work.
- Isolate and earth conductors so they are no longer energised.
- Operate circuit breakers sequentially based on the location of potential fault conditions.
- Prove deenergised
- Prevention of inadvertent energization – LOTO

Substitution – Replacing the higher risk activity with a lower risk. Replacing a standard switchboard with one that has been designed and tested for arc-resistant construction.

- Replace non-arc-rated equipment with higher rated equipment.
- Replace slow-acting fault clearing devices with faster devices.

Isolation of hazard which can be achieved by working on de-energised (and earthed) electrical equipment or using techniques like remote switching/racking.

- Restrict proximity to energised electrical plant.
- Restrict switch rooms and substations to authorised and restricted area inducted personnel only.
- Use arc flash boundaries.
- Restrict access when switching or live work is undertaken.
- Use remote switching and racking equipment.
- Follow permit to work system and electrical safety procedure.
- Keep away from the arc flash boundary.

Engineering controls such as arc flash resistant switchboards designed to contain and redirect the arc flash. Alternately, incorporating faster protection settings during maintenance work using remote rackable circuit breakers.

- Optimised protection settings
- Arc flash incident energy reduction
- Arc flash sensors
- Arc flash protection
- Insulated tools and test equipment
- Use of calibrated and tested test equipment

Administrative controls such as permits to work, signs, barriers and similar processes that ensure consistent work methods that minimise risk.

- Work access/permit system
- Permit system for live and energised low voltage work.
- Risk assessment
- Job briefing
- Arc flash labels

Personal Protective Equipment PPE and Clothing.

- Safety glasses
- Safety boots
- Ankle to wrist nonflammable clothing
- Arc flash PPE (see below)

3.0 Arc Rated Clothing and PPE

Personal Protective Equipment (PPE) controls reduce the arc flash energy reaching the skin, in the event of an arc flash. In the case of arc flash hazards, the main purpose of PPE is to reduce burn injury to a level of curable burn. PPE may or may not provide adequate protection in the case of arc flash exposure. PPE must not be used as a substitute for common sense and safe work practices.

It is critical that arc flash PPE covers all other clothing that can be ignited, there is no exposed skin, and that no fasteners or jewelry is being worn that will absorb heat in an arc flash and result in continued burning.

The minimum PPE standards for access near energized electrical equipment on WNR sites are:

- Safety glasses,
- Safety boots,
- Ankle to wrist non-flammable clothing,
- Insulated gloves for exposure to live low voltage,
- Insulated tools for exposure to live low voltage,

3.1 Cat 2 Arc Flash PPE

When work is being carried out on specific plant, under particular circumstances (e.g. normal operation, after fault, commissioning) Cat 2 arc flash PPE may be mandatory where the deemed arc flash incident energy is between 2-8 Calories per square cm. These scenarios are outlined in section 3.3 *PPE Requirements*. The below personal issue Cat 2 Arc Flash PPE shall be used as stipulated in the site-specific *PPE Requirements* table and/or as stipulated on the specific plant arc flash signage.

- **Baseball cap hood with visor** – provide high level of protection to face, neck, head and airways.
- **1000v natural rubber insulated electrical gloves** – used to provide protection from the risk of electric shock, should be worn in conjunction with cowhide outer gloves to provide protection from thermal effects of an arc.
- **Cowhide outer glove** - to be worn over rubber insulated gloves.
- **Soft cotton gloves arc 2 gloves** – used for situations where there is the possibility of exposure to incident energy above 1.2cal/cm², but where insulating gloves are not required.
- **Coverall**

Figure 1: WNR Personal Issue Arc Flash PPE Kit Contents



It is critical that arc flash PPE covers all other clothing that can be ignited, there is no exposed skin, and that no fasteners or jewelry is being worn that will absorb heat in an arc flash and result in continued burning.

3.2 Cat 4 Arc Flash PPE

Cat 4 arc flash PPE is only available at Bluff Point Wind Farm and shall be used under any work scenario where personal issue CAT 2 PPE is not sufficient (i.e. where the deemed arc flash incident energy exceeds 8 Calories per square cm).

Figure 2: WNR Cat 4 Arc Flash Kit

- Coat
- Leggings
- Hood
- Gloves



3.3 PPE Requirements

PPE has been specified based on incident energy calculations of specific equipment and is based on switching actions in specific operational circumstances/states. At the completion of the remodeling exercise, the relevant equipment (specified below) will be labelled to provide workers with clear guidance and the source of the activity (as per Section 4). In the interim, workers should gain a thorough understanding of this table and where necessary insert content into risk assessment documentation.

If a circumstance arises where worker/workers are unsure as to the arc flash PPE requirement, then it shall be assumed that Cat 2 PPE is required.

3.3.1 Definitions

The below definitions shall be considered when determining arc flash PPE requirements.

Normal Operation: Accessing, operating, testing for dead and fault finding under normal circumstances, where there is no recent history of a short circuit fault, mechanical stress, other significant event, or newly replaced components.

Unconfirmed State: An elevated risk condition involving accessing, operating, and testing immediately following a significant event causing electrical and/or mechanical stress and where the equipment has operated, or hasn't operated as intended, and hasn't yet been proven healthy and safe for continued operation. This also includes the first live local operation of equipment following replacement (such as commissioning).

Significant Event: An event causing elevated electrical and/or mechanical stress to a component or system. Short circuit fault currents, for example, generate high localised temperatures and large magnetic forces in conductors and switchgear which can reduce insulation condition and cause physical damage to internal components, increasing the risk of further damage or explosion when operated.

Live Testing: Any activity where electrical contact is made between test equipment and the electrical components in a cabinet, including test-for-dead and tracing of voltages for low voltage equipment, and the risks documented under an approved JHA or other risk assessment.

Table 1: Bluff Point Wind Farm PPE Requirements

Plant	Activity	PPE - Normal Operation	PPE – Unconfirmed State
Station Services Supplied LV	Working on.	CAT 0	CAT 0
	Live testing.	CAT 2	CAT 2
22 kV Main HV Switchboard	Switching circuit breakers locally.	CAT 2	CAT 2
	Racking Feeder circuit breakers.	CAT 2	CAT 2
	Racking HV Incomer (A552) – energised.	CAT 3	CAT 3
	Racking HV Incomer (A552) with A152 CB open.	CAT 0	CAT 0
	Working in close proximity to switchboard.	CAT 0	CAT 0
22 kV RMU (Tower Base)	Operating HV switchgear	CAT 2	CAT 2
	Working in close proximity to switchboard.	CAT 0	CAT 0
WTG LV Panel (Generator Out of Service)	Live testing A1 panel (test for dead in adjacent panel without CAT 2 PPE is acceptable)	CAT 2	CAT 2
	Live testing load side of Q15 (all other panels)	CAT 0	CAT 0
	Switching Q7, Q8, Q15	CAT 0	CAT 2
	Working in close proximity to switchboard.	CAT 0	CAT 0
125 V DC Battery Bank	Live work, live testing, visual inspection exposed live parts.	CAT 2	CAT 2
	Working in close proximity to battery bank	CAT 0	CAT 0
110 kV Switchyard	Switchyard Access	CAT 0	CAT 0
	Switching 110kV Disconnecter	CAT 0	CAT 0
	Switching 110kV Circuit Breaker (Local) – Check SF6 levels before switching	CAT 0	CAT 0

Table 2: Studland Bay Wind Farm PPE Requirements

Plant	Activity	PPE - Normal Operation	PPE – Unconfirmed State
Station Services Supplied LV	Working on.	CAT 0	CAT 0
	Live testing.	CAT 2	CAT 2
22 kV RMU (Tower Base)	This equipment has front facing internal arc classification (IAC). Under all circumstances the operator shall ensure: - The equipment is in good working order. - All doors and panels are secure. - During switch operations be positioned directly in front of the RMU (not to the side or rear) - Ensure all other personnel are clear of the tower entry level.	Arc Flash PPE is not required to operate this equipment.	Arc Flash PPE is not required to operate this equipment.
22 kV Main HV Switchboard	This equipment has front facing internal arc classification (IAC). Under all circumstances the operator shall ensure: - The equipment is in good working order. - All doors and panels are secure. - Perform switching remotely where possible. - Isolate the supply upstream before racking in the 22 kV incomer.	Arc Flash PPE is not required to operate this equipment.	Arc Flash PPE is not required to operate this equipment.
WTG LV Panel (Generator Out of Service)	Live testing A1 panel (test for dead in adjacent panel without CAT 2 PPE is acceptable)	CAT 2	CAT 2
	Live testing load side of Q15 (all other panels)	CAT 0	CAT 0
	Switching Q7, Q8 - Do not operate Q7 and Q8 live following a fault if Arc Flash Sensors NOT operational (controller is off), isolate supply at RMU	CAT 0	DO NOT OPERATE
	Switching Q7, Q8 - Arc Flash Sensors Operational	CAT 0	CAT 2
	Switching Q15	CAT 0	CAT 2
	Working in close proximity to switchboard	CAT 0	CAT 0
125 V DC Battery Bank	Live work, live testing, visual inspection exposed live parts.	CAT 2	CAT 2
	Working in close proximity to battery bank	CAT 0	CAT 0
110 kV Switchyard	Switchyard Access	CAT 0	CAT 0
	Switching 110kV Disconnectors	CAT 0	CAT 0
	Switching 110kV Circuit Breaker (Local) – Check SF6 levels before switching	CAT 0	CAT 0

Table 3: Musselroe Wind Farm PPE Requirements

Plant	Activity	PPE - Normal Operation	PPE – Unconfirmed State
Station Services Supplied LV	Working on.	CAT 0	CAT 0
	Live testing.	CAT 2	CAT 2
33 kV RMU (Tower Base)	This equipment has a front and lateral facing internal arc classification (IAC). Under all circumstances the operator shall ensure: - The equipment is in good working order. - All doors and panels are secure. - During switching operations be positioned directly in front of the RMU (not the side or rear) - Ensure all other personnel are clear of the tower entry level.	Arc Flash PPE is not required to operate this equipment.	Arc Flash PPE is not required to operate this equipment.
Main 33 kV Switchboard	This equipment has a front and lateral facing internal arc classification (IAC). Under all circumstances the operator shall ensure: - The equipment is in good working order. - All doors and panels are secure. - Perform switching remotely where possible.	Arc Flash PPE is not required to operate this equipment.	Arc Flash PPE is not required to operate this equipment.
WTG LV Panel (Generator Out of Service)	Live testing A1 panel (test for dead in adjacent panel without CAT 2 PPE is acceptable)	CAT 2	CAT 2
	Live testing load side of Q15 (all other panels)	CAT 0	CAT 0
	Switching Q7, Q8 - Do not operate Q7 and Q8 live following a fault if Arc Flash Sensors NOT operational (controller is off), isolate supply at RMU.	CAT 0	DO NOT OPERATE
	Switching Q7, Q8 - Arc Flash Sensors Operational	CAT 0	CAT 2
	Switching Q15	CAT 0	CAT 2
	Working in close proximity to switchboard	CAT 0	CAT 0
125 V DC Battery Bank	Live work, live testing, visual inspection exposed live parts.	CAT 2	CAT 2
	Working in close proximity to battery bank	CAT 0	CAT 0
220 V AC Battery Bank	Live work, live testing, visual inspection exposed live parts.	CAT 2	CAT 2
	Working in close proximity to battery bank	CAT 0	CAT 0
110 kV Switchyard	Switchyard Access	CAT 0	CAT 0
	Switching 110kV Disconnectors	CAT 0	CAT 0
	Switching 110kV Circuit Breaker (Local) – Check SF6 levels before switching	CAT 0	CAT 0

3.4 PPE Care and Maintenance

Personal issue arc flash PPE is the responsibility of the user as with other personal issue PPE such as helmets, glasses, safety boots and hi-vis clothing.

Arc rated clothing should be cleaned and maintained in accordance with the manufacturers recommendations. Dirt, oil, chemicals, and other contaminants can easily wear down the flame-fighting properties of arc flash clothing, so it's very important that FR clothing is washed as soon as possible after being soiled. And never re-wear arc flash clothing without laundering it first – dirty PPE is less effective than clean and can increase the risk of injury.

- **Inspect for damage** - Even small tears and cuts can greatly reduce the protective powers of FR clothing, so it's important to regularly inspect arc flash clothing for signs of wear and damage. If damage is found, either repair it in accordance with the manufacturer's specifications (special flame-resistant fabric patches and/or thread may be required) or replace the damaged article of clothing immediately. Never continue to wear damaged PPE, as can greatly increase your risk of on-the-job injury.
- **Laundering** – when it comes to laundering arc flash clothing gentler is better. Generally, a cold machine wash (or hand wash) with detergent is best, do not bleach or tumble dry. Always refer to the care instructions of the item.
- **PPE Replacement** – Arc flash PPE requires an in depth assessment and possible replacement after 5 years of use.

1000v natural rubber insulated electrical gloves.

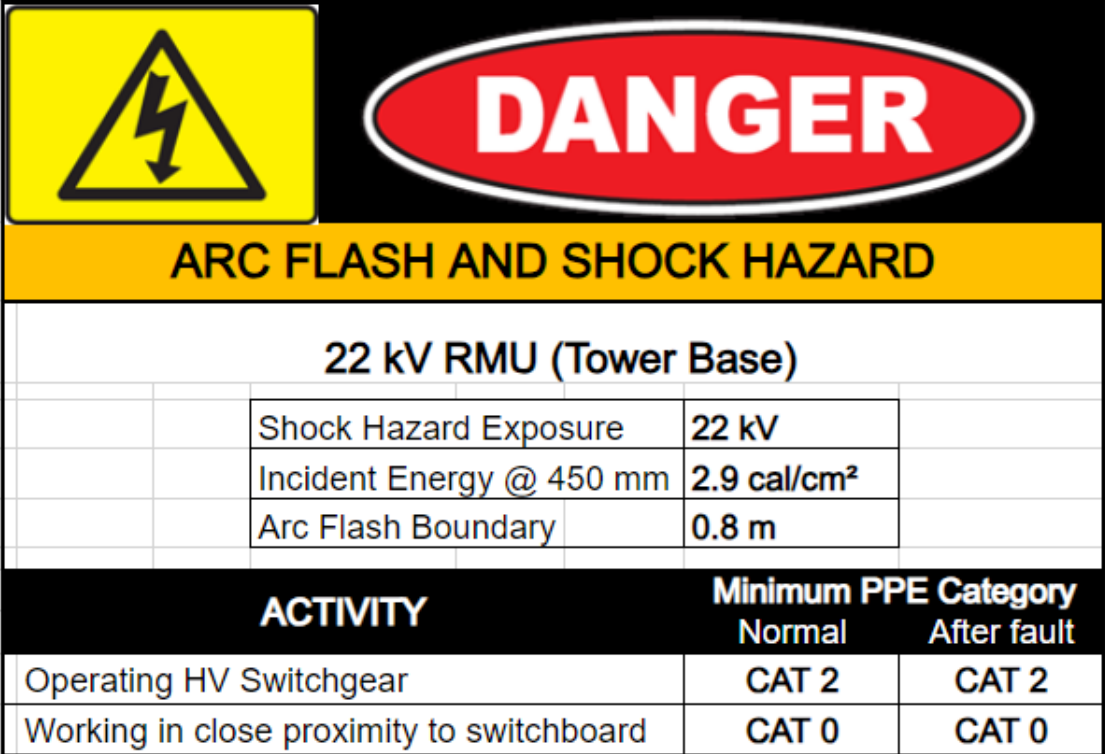
- **Testing** – gloves are to be routinely tested every 6 months, and before and after each use. Tests shall consist of air inflation to check for air leaks and a visual inspection whilst pressurised. Any glove failing this test shall be removed from service and discarded.
- **Storage** - gloves should be stored unfolded in glove bag provided.
- **Precautions in use** – care should be taken to avoid mechanical damage caused by abrasions or sharp edges. Gloves should not be exposed unnecessarily to heat or light or allowed to come into contact with solvents, oils or other chemical agents.
- **Cleaning** – when gloves become soiled, they should be washed in soap and water, at a temperature not exceeding 30 degrees Celsius, thoroughly dried and dusted with talc.

For full manufacturer recommendations concerning the storage, examination, precautions in use and cleaning refer to glove packaging.

4.0 Arc Flash Labelling

Arc flash labelling and warning signage is located at the point of risk. Arc flash signage will be consistent with the AEC – Electrical Arc Flash Management Guideline, see example below.

Figure 3 – Example Arc flash label for relevant equipment.



22 kV RMU (Tower Base)			
		Shock Hazard Exposure	22 kV
		Incident Energy @ 450 mm	2.9 cal/cm ²
		Arc Flash Boundary	0.8 m

ACTIVITY	Minimum PPE Category	
	Normal	After fault
Operating HV Switchgear	CAT 2	CAT 2
Working in close proximity to switchboard	CAT 0	CAT 0

5.0 Accountabilities

All staff within WNR conducting operational activities must ensure So Far As Reasonably Practicable (SFARP) that they understand the requirements of this procedure and that their activities are in compliance with this procedure.

All staff and contract managers are to ensure the operational personnel they are responsible for have access to this procedure, understand the core requirements of this procedure and that they are provided with adequate supervision to minimise the risks of arc flash incidents.

The HSE Manager for WNR is to ensure SFARP that this procedure reflects industry best practice, meets National and State legislative requirements and Standards and that this document is maintained within the Plan-Do-Check-Act cycles of the businesses HSE system.

6.0 References

The following manuals and references are to be used for assisting in managing hazards and controls associated with arc flash on WNR wind farms.

- Safe Work Australia Code of Practice – Managing electrical risks in the workplace.
- AEC – Electrical Arc Flash Management Guideline
- C519238-R-01 Bluff Point Wind Farm Arc Flash Study Report Rev 2
- C519238-R-02 Studland Bay Wind Farm Arc Flash Study Report Rev 1
- C519238-R-03 Musselroe Wind Farm Arc Flash Study Report
- Energy Networks Australia (ENA) Guideline NENS-09 2014 National Guideline for the Selection, Use and Maintenance of Personal Protective Equipment for Electrical Arc Hazards