8.3 Induced Voltage

**Purpose**

The purpose of this instruction is to provide awareness to all Horizon Power Workers, including Workers operating, servicing, and/or maintaining (MPS) Micro Power Systems electrical equipment (inclusive of all generating methodologies) about Electrostatic and Electromagnetic induced voltages and the method required to reduce or eliminate it.

An induced voltage is often simply referred to as “induction”.

There are several potentially hazardous conditions routinely found on equipment connected to the electrical network including earthing conductors and interconnected structures.

These hazardous conditions can cause a fatal electric shock and include:

- Induced voltages from electromagnetic induction and capacitance
- Transient voltages from lightning and some high voltage (HV) switching surges
- Earth potential rise (EPR) and the resulting step and touch potential

While these conditions are more likely to be found during a fault somewhere on the electrical network or during storm conditions, they can also occur during normal working conditions.

**Scope**

This instruction applies to all Horizon Power Workers, including Workers operating, servicing, and/or maintaining (SPS) Standalone Power Systems electrical equipment (inclusive of all generating methodologies) who work on Horizon Power electrical assets that are or have the potential to cause Induced Voltages, and must be complied with at all times when working:

- On or near Horizon Power’s electrical assets

**Safety**

Before commencement of work, a risk assessment must be carried out using the Risk Analysis Procedure (OSH-3.6-1-02), to identify and document the hazards and risks associated with the task and ensure appropriate control measures are implemented.

It is important that, appropriate control measures must be identified, documented and implemented in order to control hazards to As Low as Reasonable Practicable (ALARP).

**Instruction**

Induced voltages that are generated may be as little as a few volts and as high as many kilovolts and could be hazardous or life threatening if the correct procedures are not followed.

Induced voltages can occur in overhead lines, underground cables, or in switchyards.

Wherever a line is adjacent to or connected to lines/cables which run near live parts of the system, induced voltages can develop (particularly if a fault occurs on the other line).

Induced voltages most often occur between an energised line and a non-energised line, but can occur wherever there are parallel conductors.
Induced voltages may occur (especially during fault conditions) in the following:

<table>
<thead>
<tr>
<th>Out of service power cables</th>
<th>Aerial pilot cables and earth wires</th>
<th>Communication cables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead conductors</td>
<td>Cable sheaths</td>
<td>Cross-bonding cables</td>
</tr>
<tr>
<td>Steel and concrete poles</td>
<td>Double-circuit lines</td>
<td>Lines running together for part of their length</td>
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<tr>
<td>Catenary wires</td>
<td>Pipelines</td>
<td>Conveyors.</td>
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</tbody>
</table>

Factors affecting the level of induced voltage are:

- Strength of the electromagnetic field being produced around the energised conductors
- Distance that the lines/cables runs parallel to each other, and
- Proximity (closeness) of the lines/cables to each other.

The value of an **Electrostatic** induced voltage depends on the voltage of the inducing conductor/line (energised apparatus) or changes in voltage due to switching or faults.

The value of an **Electromagnetic** induced voltage depends on the:

- Distance that new or isolated aerial conductors run parallel to an inducing conductor/line that can considerably increase the amount of induced voltage.
- Separation distance between the inducing conductor/line and the new or isolated apparatus.
- Amount of current flowing in the inducing conductor/line due to load or faults.

In some cases, an inducing conductor/line crossing at right angles to a new or isolated line can create induced voltages.

Electrical apparatus such as transformers and cables, including the associated metalwork, which is close to live HV apparatus, can have a voltage induced into it.

The value of an induced voltage will influence the number of working earths required and the proximity of the working earths to a person’s working position.

**Job Risk Assessments (JRA)** must take into consideration the effects of induced voltages for all tasks that involve working on new or isolated electrical apparatus.

**Transient Voltages**

During a lightning strike and during some switching operations on the electrical network, large voltages and currents can be transferred onto other equipment (such as listed above) and to remote locations of the network. Switching surges and lightning transient voltages and currents can present a serious hazard.

Certain parts of the electrical network (such as cable screens, earth continuity conductors and neutral conductors) must remain earthed whenever in service. They should not be disconnected from earth unless required as part of replacement or planned work.
Earth-Potential Rise

Earth potential rise (EPR) occurs when electrical current enters the ground (e.g. due to a flash-over or fallen or damaged cables) and can lead to a Step and Touch Potential and/or a Transferred Earth Potential hazard.

Step and Touch Potential

Step and touch potential issues are shock hazards resulting from an earth potential rise. Step potential occurs when you have your feet at different points in the potential gradient. The resulting potential difference can result in a shock. Touch potential is the potential difference between the ground on which you are standing and a metal object which might be touched (such as a fence, a water tap or earthed equipment in the electrical network).

Transferred Earth Potential

During fault conditions, the earth potential rise can be transferred along any conductor to a remote location. A person may receive a shock by touching the conductor and the local soil. Some examples of transferred earth potential rise include:

- metal pipes (water or gas pipes)
- copper (or other metallic) wires, such as cable screens or armouring
- fencing (especially if a neighbouring fence connects to a substation fence)
- railway lines
- underground cables
- concrete (such as a steel reinforced concrete driveway next to a substation)

Working on conductors exposed to induced voltages

To ensure no potential difference exists across the worker’s body, and all personnel are fully protected from induced voltage, evaluate from the risk assessment the appropriate action using one or more of these methods:

- apply earths, as specified in Field Instruction 6.1 Portable Earthing Requirements
- apply equipotential bonding methods and/or
- use insulating techniques

Important

When working on de-energised power lines, the installation of remote programmed earths may not always protect the workers from the dangers of induced voltage.

Always maintain working earths within five metres of the worksite on each incoming power line (box in) or as close as practicable to the worksite.
**Working Earths**

Where the job risk assessment suspects induced voltages are present, additional working earths must be installed at the work-site to eliminate the effects of any induced voltage.

Working earths may be periodically moved or placed at the immediate work-site to ensure induced voltages are eliminated or kept to a minimum.

Where additional working earths are placed either side of the immediate work-site or open point, the earth grounding leads must be bonded together at the earthing point to create an equipotential work zone.

**Uninsulated Elevated Work Platform (EWP)**

Uninsulated EWP’s working within substation sites must:

- Have the basket bonded to the electrical apparatus being worked on; and
- The vehicle earthed to a known earth point using the approved earthing leads (either bolted or clamped).

Where possible, leave all Earth Switches “ON” at substation sites, unless they are required to be opened for testing purposes.

Before any Earth Switches are opened, ensure all personnel are made aware of the changes to the yard configuration / earthing arrangements within their relevant work area.

**Earthing the EWP**

When travelling in a live substation, securely attach a trailing 10 mm diameter bright or galvanised drag chain to the EWP (minimum 150 mm of chain in contact with ground).

Earth the EWP to the substation earth grid.

Before use, inspect the earth lead and confirm:

- that the test date is not expired
- the tightness of bolted connections
- the general condition of earthing leads

When working in a substation the earth leads must be a minimum of 150 mm² aluminium.

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**Note:** When using multiple uninsulated access equipment (EWP’s and scaffolding) ensure all pieces of equipment are bonded together.
Transmission Power lines entering Substations

When disconnecting an incoming transmission power line from the substation, establish an equipotential zone using the techniques below:

- Bond the power line outside the substation to the first tower or to the running earth
- Use bridging conductors when breaking a conductor.
- Bond the tower or running earth to the substation earth grid (see Figure 11 below)
- Situate working earths within five metres of each side of the work area.

Another measure to consider is an earth mat around the base of the tower if the risk assessment indicates a high risk of induced voltage.

![Figure 11: Example of a matted area where disconnecting or stringing a new conductor into a substation](image)

Note: Higher voltages, higher currents and longer areas of close proximity between energised and de-energised conductors/cables, all contribute to increasing the risk and severity of induction on the de-energised conductors/cables.
References

- Occupational Safety & Heath Act 1984
- Occupational Safety & Health Regulations 1996
- SHMS OSH-3.6-1-02 Job Risk Analysis (JRA) Procedure
- SHMS OSH-3.6-1-26 Personal Protective Equipment
- Horizon Power Electrical Safety Standards
- Field Instruction 2.5 Other Personal Protective Equipment
- Field Instruction 2.6 Worksite Clothing / Personal Protective Equipment Requirements
- Field Instruction 2.7 Safety Requirements when Working from an EWP
- Field Instruction 2.13 Vehicle and Plant Earthing Requirements
- Field Instruction 2.17 Safe Approach Distances
- Field Instruction 2.23 Job Hazard and Risk Management (JRA)
- Field Instruction 2.25 Test Before You Touch Prior to Commencement with Work
- Field Instructions 4.1 Substation Entry Requirements
- Field Instruction 4.3 Substation Clearances
- Field Instruction 5.4 Testing and use of High Voltage Insulated Equipment
- Field Instruction 8.1 Portable Earthing Requirements

Further Reading

- Electricity Supply Association of Australia, Work on Cables Under Induced Voltages – Application Guide, D(b)26-1995