EXPERT TECHNOLOGY TOOLS

WTIA

Welding Technology Institute of Australia

TGN-W-05

Earthing of mobile generating sets

1. Objective

The objective of the guidance note is to provide guidance on the correct use of residual current devices (RCDs) and earthing, on engine driven mobile welding generating sets, to minimise the risk of electric shock to personnel. The guidance given is limited to mobile engine driven generating sets that provide power for welding with auxiliary outlets supplying single-phase 230 Volt a.c. or three-phase 400 Volt a.c. and does not apply to larger generating sets that supply switchboards using the multiple earthed neutral (MEN) system of earthing.

This guidance note provides an overview of the requirements of Australian Standards with particular attention to the correct use of residual current devices (RCDs), the correct use of equipotential bonding and highlights the arguments for and against earthing.

The ultimate objective is to make the Australian fabrication industry more competitive by improving the safety of welding operations, the quality of welded products and reducing fabrication costs.

2. Introduction

Engine driven mobile welding generators have been successfully used in the construction and maintenance industries for decades. In some cases the generator has an auxiliary power generation capability and may be fitted with single-phase 230 Volt a.c. or three-phase 400 Volt a.c. outlets. It is a requirement of a number of Australian Standards that these auxiliary outlets be fitted with an RCD. Refer AS/NZS 3012.

There are differences of opinion in industry regarding the use of earthing for mobile generators to ensure correct operation of RCDs and provide optimum protection of personnel against exposure to electric shocks.

In order for an RCD to be effective it must be connected correctly to the circuit in such a way that the RCD detects and immediately responds to an earth leakage current when it occurs. It is critical that all exposed conductive parts are connected to the generator set equipotential bonding system. In particular, any conductive part of the job the welder is working on must be connected to the generator set equipotential bonding system by an independent bonding conductor.

3. Residual Current Devices

A residual current device is defined in AS/NZS 3190 as *"a mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when residual current attains a given value under specified conditions"*. An RCD is defined in AS/NZS 3000 and AS/NZS 3012 as *"a device intended to isolate supply to protected circuits, socket-outlets or electrical equipment in the event of a current flow to earth which exceeds a predetermined value. RCDs are classified in AS/NZS 3190 and AS/NZS 3175."*

A residual current device (RCD) is intended to isolate supply to protected circuits, socket-outlets or electrical equipment in the event of a current flow to "earth" that exceeds a predetermined value. For a mobile generator used on an industrial site the maximum value is 30 mA (milli-Amp). Refer AS/NZS 3012 Clause 2.4.6.3.

That value corresponds with a RCD Type II classification as defined in AS/NZS 3190 Section 4. *"Type II RCDs and relays with a rated residual current ($I_{\Delta n}$) exceeding 10 mA but not exceeding 30 mA."*

RCDs are designed to detect an imbalance in the current flowing in the active and neutral conductors of a circuit. If there is a fault current to earth that results in an imbalance of greater than the trip value, the RCD should trip and render the circuit safe. The maximum trip current for this application is 30 mA.

4. Location of RCDs

AS/NZS 3000 requires that *"Any device for protection against earth-leakage current shall be capable of interrupting the part of the circuit protected by the device when an earth-leakage current is flowing above a predetermined value. Devices shall be residual current devices (RCDs) complying with AS/NZS 3190, AS/NZS 3175 or AS/NZS 61009.1."*

RCDs must therefore be located within a circuit "upstream" of that part of the circuit being protected and downstream of the MEN or NE connection. All exposed conductive parts must be bonded to the equipotential bonding system of the generating set. Details of RCD location are given in AS 2790, AS/NZS 3010 and AS/NZS 3012.

5. Equipotential Bonding and Earthing Systems

5.1. What the Australian Standards Say

5.1.1. AS/NZS 3000:2000 – Australian/New Zealand Standard Wiring Rules

Earthed is defined as *"Connected to the general mass of earth in accordance with the appropriate requirements of this Standard."*

Equipotential bonding is defined as *"Special electrical connections intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential, but not intended to carry current in normal service."*

5.1.2. AS/NZS 3010:2005 – Electrical installations—Generating Sets

Refer AS/NZS 3010, Section 2, Clause 2.5.6 EARTHING AND BONDING.

*"**2.5.6.1 Generating set bonding system.** The following parts of the generating set shall be electrically bonded together to form the generating set bonding system:*

(a) The engine frame.

(b) The generator frame.

(c) All exposed conductive parts enclosing electrical equipment or wiring.

(d) The 'earth' terminals of any socket-outlets.

(e) The main frame terminal

2.5.6.2 Generating set windings.

2.5.6.2.1 Multiphase and single-phase centre-tapped generating sets

In general, the following points of the generating set windings, where appropriate, shall be connected to the generating set bonding system:

(a) The neutral or star point of a three-phase winding.

(b) The neutral point of a two-phase winding.

(c) The centre-point of a single-phase centre-tapped winding.

This requirement shall not apply where, in accordance with Clause 2.5.6.3.2(a), the above points are connected to the earthing system of an electrical installation."

There is no indication in the above requirements for the generating set bonding system to be connected to earth.

2.5.6.2.2 Single-phase (other than centre-tapped) generating sets

In general, no points of a single-phase winding, other than the centre-tapped type referred to in Clause 2.5.6.2.1.(c), shall be connected to the generating set bonding system.

This requirement shall not apply where a generating set supplies one or more items of electrical equipment –

(a) by individual attachment; or

(b) as a part of an electrical installation that does not incorporate an earthing system;

and the connection is required for a protection system that ensures the disconnection of the electrical installation, or the individually attached appliances, as appropriate, in the event of an earth fault.

There is no indication in the above requirements for the generating set bonding system to be connected to earth.

2.5.6.3 Generating sets used with electrical installations with an earthing system

2.5.6.3.1 Connection of generating set bonding system. *Where a generating set supplies an electrical installation that incorporates an earthing system, the bonding system of the generating set (see Clause 2.5.6.1) shall be earthed by connection to the earthing system of the electrical installation.*

Connection to earth shall not be made by means of a separate earth electrode.

The generating set bonding system is required to be connected to the electrical installation earthing system in this situation but not via a separate earth electrode.

Refer AS/NZS 3010, SECTION 4, which details additional requirements for plug and socket-outlet connected generating sets.

Clause 4.2 EARTHING AND BONDING

4.2.1 General. *The earthing and equipotential bonding requirements for plug and socket-outlet connected generating sets shall be as specified in Clause 2.5.6.*

Particular attention is drawn to the provisions of Clauses 2.5.6.3.1 and 2.5.6.4 which require the generating set bonding system to be connected to the exposed conductive parts of any equipment being supplied by the generating set and, in certain circumstances, connected to the earthing system of the electrical installations.

4.2.2 Connection of generating set windings.

4.2.2.1 Multiphase and single-phase centre-tapped generating sets. *The neutral or centre-point of the generating set windings shall be connected to —*

(a) the generating set bonding system in accordance with Clause 2.5.6.2.1; or

(b) the neutral conductor of the electrical installation in accordance with Clause 2.5.6.3.2.

4.2.2.2 Single-phase (other than centre-tapped) generating sets. *The connection of the generating set winding to the generating set bonding system shall be in accordance with Clause 2.5.6.2.2. This does not preclude an indirect connection occurring between one side of the generating set winding and the generating set bonding system where —*

(a) the generating set winding is connected to the neutral of an electrical installation in accordance with Clause 2.5.6.3.2; and

(b) the earthing system of the electrical installation is permitted to be connected to the neutral of the electrical installation.

4.2.3 Earth electrode

The connection of a generating set bonding system to the general mass of the earth through an earth electrode is not required or recommended."

AS/NZS 3010:2005 Clause 4.2.3 states that earthing of plug and socket-outlet connected generating sets complying with the principles of AS 2790 is not required or recommended.

5.1.3. AS/NZS 3012:2003 – Electrical installations—Construction and demolition sites

Refer AS/NZS 3012 Clause 2.4.6.3

*"**2.4.6.3 Electrical equipment supplied by low-voltage generators***

LV generators, complying with the principles of AS 2790 shall be connected as follows:

(a) Switchboards supplied directly by a generator shall provide protection to all sub-mains and final sub-circuits as illustrated in Figure 2.1.

(b) Isolated winding generators, connected in accordance with Figure 2.2, may be used to supply a separated circuit for electrical equipment installed in accordance with the electrical separation requirements of AS/NZS 3000 and with each winding supplying not more than one item of Class I (earthed conductive parts) electrical equipment.

NOTE: This description includes a single winding supplying one or more items of Class II (double insulated) electrical equipment and a single winding supplying one item of Class I (earthed conductive parts) electrical equipment plus one or more items of Class II (double insulated) electrical equipment.

(c) Generators providing electrical supply via permanently connected RCDs with maximum rated residual current of 30 mA, operating in all live (active and neutral) conductors, and connected as per Figure 2.3 may be used to supply multiple items of equipment.

Earthing of the generator frames is not required, nor recommended. No earth electrode is required."

Refer AS/NZS 3012 Section 3 Clause 3.7

"3.7 CONNECTION BETWEEN GENERATOR WINDINGS OR FRAME AND EQUIPOTENTIAL BONDING SYSTEM

(a) Where an RCD is used with, or connected to, a generator, the integrity of the connection between the generator windings and the equipotential bonding system on the generator (Refer to Figure 2.3) shall be tested using an RCD tester.

NOTE: This test may be performed in conjunction with the test for operating time of an RCD used with a portable generator of Clause 3.5.

(b) Where an isolated winding generator in compliance with Clause 2.4.6.3(b) is used, the continuity of the connection from the frame to the equipotential bonding system (Refer to Figure 2.2) shall be tested."

This standard states, *"earthing of the generator frames is not required, nor recommended. No earth electrode is required"*. When an RCD is used there is a requirement for regular inspection and testing of the equipotential bonding between the generating set and any exposed metal of any equipment being supplied by the generating set. Clause 3.1 of AS/NZS 3002:2002 – Electrical installations – Shows and carnivals, also states the same thing.

6. Explanation of Welding Circuits, Auxiliary Power Circuits, Equipotential Bonding Circuits and Earthing

6.1. Welding Circuits

Welding circuits consist of an electrode lead and a work or return lead. The electrode lead connects the welding power source to the electrode handpiece in the case of manual metal arc welding (MMAW) or a wire feeder unit in the case of gas metal arc welding (GMAW) and flux cored arc welding (FCAW). The work or return lead connects the work piece to the welding power source to complete the welding circuit. Refer AS 1674.2 and WTIA Technical Note 22 for information on correct connection of electrode and work return leads.

The work return lead is often incorrectly referred to as the “earth lead”. This incorrect terminology adds to misunderstanding of the function of the welding circuit. There is no requirement for any part of a welding circuit to be earthed. Welding circuits are inherently safer if they are not connected to earth. AS 1674.2 cautions against the use of earth circuits to form any part of welding return lead paths. Welding current paths in conductors other than the electrode lead, work lead and workpiece are considered to be fault currents and expose welders and others in the vicinity to an electric shock hazard.

6.2. Auxiliary Power Circuits

It is a requirement that auxiliary socket outlets on mobile generating sets are protected by an RCD. RCDs must be installed in accordance with the requirements of AS/NZS 3010 and AS/NZS 3012. Equipment connected to the auxiliary socket outlets must have its “earth” conductor connected to the equipotential bonding system of the generating set.

6.3. Equipotential Bonding Circuits

Equipotential bonding systems are intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential. For an RCD to detect and respond to all possible leakage currents, the “earth” reference of the RCD must be connected to all possible conductors that the protected circuit could come in contact with.

Equipotential bonding must include the equipotential bonding system of the generating set, the metal structure or component that is being worked on and any other conductive parts that the auxiliary circuits could come in contact with. Care is required to ensure that all possible conductors are included in the equipotential bonding system.

6.4. Earthing Circuits

In some cases the structure or component being worked on will be effectively earthed, however this is not necessarily the case and earthing should never be assumed to exist. An earth electrode connected to the equipotential bonding system of the generating set may have been used to earth the generating set.

Ground conditions can vary from time to time and from location to location so there may be significant earthing system impedance and hence fault loop impedance for fault currents to exposed parts of a job. Because of the potential unreliability of earthing systems, particularly on temporary work sites it is recommended that supplementary equipotential bonding (see above) be used in preference to earthing.

The work or return lead of the welding circuit **is not** an earth nor does it provide equipotential bonding to the equipotential bonding system of the generating set.

7. Summary

7.1. Residual Current Devices

It is a requirement of a number of Australian Standards that auxiliary circuits be fitted with a residual current device (RCD). Refer AS/NZS 3010 and AS/NZS 3012.

An RCD is intended to isolate supply to protected circuits, socket-outlets or electrical equipment in the event of a current flow to “earth” that exceeds a predetermined value. For a mobile generation set used on an industrial site the maximum value is 30 mA (milli-Amp). Refer AS/NZS 3012 Clause 2.4.6.3. That value corresponds with a RCD Type II classification as defined in AS/NZS 3190 Section 4.

In order for an RCD to be effective it must be connected correctly to the circuit in such a way that the RCD detects and immediately responds to an earth leakage current when it occurs. It is critical that all exposed conductive parts are connected to the generator set equipotential bonding system. In particular, any conductive part of the job the welder is working on must be connected to the generator set equipotential bonding system by an independent bonding conductor.

7.2. Equipotential Bonding

Equipotential bonding systems are intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential. For an RCD to detect and respond to all possible leakage currents, the “earth” reference of the RCD must be connected to all possible conductors that the protected circuit could come in contact with.

It is recommended that supplementary equipotential bonding be used to ensure that all possible conductors are included in the equipotential bonding system to reduce the fault-loop impedance in order to ensure that the disconnection time of the protective device is sufficient to satisfy the requirements of AS/NZS 3000 Clause 1.7.4.3.2 to Clause 1.7.4.3.4.

7.3. Earthing

Earthing of mobile welding generating sets is not necessary for field applications where the generating set is independent of fixed electrical installations. For generating sets not supplying to fixed installations earthing is not required by AS/NZS 3000 or AS/NZS 3010 and is cautioned against in AS/NZS 3012.

8. References

1. AS/NZS 3000:2000 – Australian/New Zealand Standard Wiring Rules
2. AS/NZS 3010:2005 – Electrical installations—Generating sets
3. AS/NZS 3012:2003 – Electrical installations—Construction and demolition sites
4. AS 3175 – Approval and test specification—Residual current-operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB’s) Part 1: General rules
5. AS/NZS 3190:2002 – Approval and test specification—Residual current devices (current-operated earth-leakage devices)

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As a valued technology expert in this area we would like you to be part of the Technology Expert Group to review this note. Please complete this questionnaire so that we can gauge the success of meeting this need.

Objective 1: Provide guidance on the correct use of residual current devices (RCDs), earthing and equipotential bonding

There are differences of opinion in industry regarding the use of earthing for mobile generators to ensure correct operation of RCDs and provide optimum protection of personnel against exposure to electric shocks. This guidance note is intended to provide an overview of the requirements of Australian Standards with particular attention to the correct use of residual current devices (RCDs), the correct use of equipotential bonding and highlight the arguments for and against earthing. How well does the document clarify the requirements for earthing and equipotential bonding?

poor ☐ average ☐ good ☐ very good ☐

Comments:

Objective 2: Identify appropriate technology receptors in the Water or other Industry sectors

This document was written for Engineering and Maintenance personnel in the Water or other Industry sectors. Are these people the appropriate individuals we should be targeting?

yes ☐ no ☐

What other types of companies and/or personnel do you suggest we target?

Objective 3: Identify and implement latest requirements of Australian Standards

The document was written to reflect current requirements of Australian Standards. Do you envisage opportunities for the implementation of the guidance note in the industry?

yes ☐ no ☐

If yes, what and where, if no why not?

Objective 4: Is the information provided clear, concise and accurate?

yes ☐ no ☐

If not, why?

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