1. SCOPE

This document provides an overview of methods to be used to verify the performance of Voltage-Reducing Devices (VRDs). The TGN refers to both daily pre-start checks to be carried out by the operator and routine tests to be carried out by a competent person as part of a safety management system.

Daily or pre-start checks are described. The operator should carry out daily or pre-start inspections, based on observation of indicators, to verify operation of the VRD before commencing work.

Routine verifications of the function of the VRD are described. A competent person, equipped with instruments capable of measuring voltage against time, is necessary for these tests.

2. INTRODUCTION

An improvement opportunity exists within the mining industry with respect to verification of the correct functioning of VRDs.

VRDs are a safety enhancement that has been available to the industry since the '90s. Following the release of recommendations of the inquiry into fatal injuries received by a boilermaker at Cannington mine in Queensland in 1997, which contained the following:

"*The Recommendations of the Reviewers are as follows:*
We acknowledge the development and implementation of the Cannington Welding Procedures, including the installation of Voltage Reducing Devices (VRD's) on all alternating current welding equipment on site and would recommend the adoption of similar procedures and personal protection devices for welding equipment at all mines.
Effective Standard Work Instructions for working in heat must be developed, implemented and enforced.
Contractors and Sub-Contractors employed on mine sites must have effective Safety Management Systems in place that clearly define the Role and Responsibility of Supervisors and their inter-relationship with the mine owners, agents or managers."

3. OBJECTIVES

The objective of this Technical Guidance Note is to provide the basis for carrying out daily or pre-start and routine verification of correct operation of a VRD. Verification should be included as part of routine safety inspections and maintenance. Refer AS1674.2 Section 5.

4. DEFINITIONS

A voltage-reducing device is a type of hazard-reducing device that reduces the open circuit voltage (OCV) or no load voltage to a safer level.

Refer Appendix A for extracts from AS 1674.2 - 2003 giving definitions of "Hazard-reducing device" (Extract 1), "Open circuit voltage (OCV) or no-load voltage" (Extract 2) and "Voltage-reducing device (VRD)" (Extract 3).

5. OPERATIONAL REQUIREMENTS

VRDs reduce the hazard of electric shock in three ways: -
VRDs reduce the OCV to a safer level when the OCV is at 200 Ohms or greater.
VRDs allow the secondary circuit to be at maximum OCV when the circuit resistance is below 200 Ohms.

VRDs limit the time the welding circuit is at maximum OCV when the circuit resistance is at 200 Ohms or greater.

The operational requirements of VRDs are given in AS 1674.2 – 2003. Refer Appendix A, Extract 5 and Extract 6.

5.1 Maximum Permitted Open-Circuit Voltage

The maximum permitted open-circuit voltage is dependent on the category of environment where the welding work is to take place. Refer AS 1674.2 – 2003 3.2.6 (Extract 5).

5.1.1 Hazard Identification and Risk Assessment

A hazard identification and risk assessment must be carried out in order to rate the category of the environment where the welding is to take place. Refer AS 1674.2 – 2003 2.2 (Extract 4).

For portable welding machines (welding power sources) that may be used in any of the environment categories, it is recommended that the equipment be tested for compliance against the requirements of the most stringent category, i.e. Category C.

If a hazard identification and risk assessment provides justification for an environment to be derated from Category C to Category B or from Category B to Category A, the allowable voltage levels for those categories may be selected.

5.2 VRD Switching Resistance

Refer AS 1674.2 – 2003 3.2.7.1 (Extract 6)
Voltage-reducing devices shall automatically reduce the rated no-load voltages to which they are connected to less than d.c. 35 V peak or a.c. 25 V rms, at a maximum resistance of the external welding circuit being 200 Ohms.

5.3 VRD Switching Times

Refer AS 1674.2 – 2003 3.2.7.1 (Extract 6)
… for d.c. output welding machines, the hazard reducing device shall operate within 0.5 s and,
… for a.c. output welding machines, the hazard reducing device shall operate within 0.3 s.

6. VERIFICATION PROCEDURES

6.1 Safety

All personnel involved in the testing and operation of welding machines shall be made aware of the inherent hazards of the secondary circuit which may be at potentially harmful voltages. Routine safety inspections require connection of electrical testing instruments to parts of the secondary circuit of a welding machine. Verification of the operation of a VRD requires operation of the welding machine.

Test equipment shall be appropriately rated for the environmental conditions, maximum voltages and currents that the instrument could be subjected to during the inspection process.

Wherever possible the instructions of the original equipment manufacturer (OEM) shall be followed when verifying the performance of the VRD.

6.2 Daily or Pre-Start Inspections

Refer AS 1674.2 – 2003 3.2.7.4 (Extract 7)

As the final part of the pre-start inspection of a welding machine it is recommended that the operator carry out a visual inspection to confirm that the indicators on the VRD are functioning in accordance with the OEM specifications and the requirements of AS 1674.2. This inspection requires power to the welding machine so the operator should take all precautions to ensure the inspection is carried out in a controlled environment.

The operator observes that the VRD indicator is functioning, either by using a test unit or by performing a trial weld.

In the event that the VRD indicator does not function correctly the welding machine shall be placed out of service until the fault can be rectified.

6.3 Maximum Open-Circuit Voltage

6.3.1 Equipment requirements

Multimeter or Voltmeter capable of measuring d.c. Voltage from 0 to 200 Volts for d.c. output welding power sources or a.c. voltage from 0 to 200 Volts for a.c. output welding power sources.

6.3.2 Test sequence

Ensure power is isolated from the welding machine.
Ensure the work lead and electrode lead are separated or disconnected from the welding power source.
Attach the test electrodes of the meter to the output terminals of the welding machine.
Activate the secondary circuit of the welding power source, i.e. turn on the power to the welding machine on or in the case of generator types, start the generator.
Record the maximum voltage on the output terminals of the welding power source.
The voltage should be less than or equal to the maximum permitted voltage for the Category of environment. For a Category C environment this is 35 Volts for a d.c. output machine or 35 Volts peak, 25 Volts rms for an a.c. output machine.

6.4 VRD Switching Resistance

6.4.1 Equipment requirements

Multimeter or voltmeter capable of measuring d.c. Voltage from 0 to 200 Volts for d.c. output welding power sources or a.c. voltage from 0 to 200 Volts rms for a.c. output welding power sources.
A load resistor having a value of 200 Ohms or slightly less.
A load resistor having a value below the resistance that allows the VRD to change to the open circuit voltage. This value must be less than 200 Ohms. The value of resistance required to return the VRD to the high voltage state may be much less than 200 Ohms. The OEM should provide details of test resistances.
Note: At a typical open circuit of a d.c. welding power source at 100 Volts, a current of 0.5 A will flow through a 200 Ohm resistor, i.e. 50Watts, a current of 5 A will flow through a 20 Ohm resistor, i.e. 500 Watts.

6.4.2 Test sequence

Connect the resistor ($\leq$ 200 Ohms) across the output terminals of the welding power source.
Connect the test electrodes of the meter to the output terminals of the welding power source.
Turn on the power to welding machine on or in the case of engine drives, start the engine.
Record the maximum voltage on the output terminals of the welding power source.
The voltage should be less than the maximum voltage for the Category of environment. For a Category C environment this is 35 Volts for a d.c. output machine or 35 Volts peak, 25 Volts rms for an a.c. output machine.

6.5 Speed of Operation

6.5.1 Equipment requirements

An instrument capable of recording voltage in the range of 0 to 200 Volts against a time base, e.g. a recording oscilloscope.
Resistor No.1 – A load resistor having a value of 200 Ohms or slightly less.
Resistor No.2 – A load resistor having a value below the resistance that allows the VRD to change to the open circuit voltage. This value must be less than 200 Ohms. The value of this resistor will vary for different types of VRDs and advice should be sought from the manufacturer.
A switch capable of carrying the current that will flow when Resistor 2 is in the circuit.

6.5.2 Test sequence

1. Connect Resistor No.2 across the output terminals of the welding power source with the switch in series. Ensure the switch is opened.
2. Connect Resistor No.1 across the output terminals of the welding power source in parallel with Resistor No.2 and the switch.
3. Connect the test electrodes of the test instrument across the output terminals of the welding power source.
4. Turn on the power to welding machine on or in the case of engine drives, start the engine.
5. Set the recording instrument to trigger on a rising voltage that exceeds the maximum permissible open circuit voltage.
6. Close the switch.
7. The voltage across the terminals should increase.
8. Open the switch.
9. The voltage across the terminals should increase to the unregulated open circuit voltage (i.e. without a VRD).
10. The voltage should return to the maximum permitted voltage with in 0.5 second in the case of d.c. output welding machines or 0.3 second in the case of a.c. output welding machines.

7. RECORD OF RESULTS

Results of the tests carried out should be kept in a suitable register.

The test results should contain the following information:

- Date of test
- Identification of the VRD tested. This would include details of the welding machine with integral VRD fitted or welding machine and after market VRD
- Identification of the competent person carrying out the test
- Reference to the test procedure used
- Identification of the testing equipment used
- Results of tests carried out
- A statement of compliance or non-compliance to AS 1674.2 requirements.

An example of a suitable form is provided in Appendix B.

Appendix A – Extracts from AS 1674.2 – 2003

Extract 1

1.3.10 Hazard-reducing device

A device designed to reduce the hazard of electric shocks from a welding circuit.

Extract 2

1.3.14 Open-circuit voltage (OCV) or no-load voltage

The voltage between output terminals of a power source, while it is switched on, but not delivering any current.

Extract 3

1.3.21 Voltage-reducing device (VRD)

A type of hazard-reducing device (either internally or externally fitted to a welding power source) that is designed to automatically reduce the open-circuit voltage to a safer level.

Extract 4

2.2 CLASSIFICATION OF WELDING ENVIRONMENT

Before welding commences, the work area shall be assessed and the welding environment classified for risk of electric shock in accordance with Clause 1.3.6. Also the following apply:

(a) *Category A environment (see Clause 1.3.6.1)* In Category A environments, considerable effort is required to insulate the welder and others from the workpiece, such as bench-top welding where the workpiece is small and there is a low risk of the welder becoming part of the circuit; or where both the welder and any assistants are prevented from being in contact with conductive parts. For repetitive operations, such an environment is usually limited to carefully designed workstations, as well as welder training and welding procedure qualification test bays.

NOTE: AS/NZS 3195 and IEC 60974-1 classify a Category A environment as 'an environment without increased hazard of electric shock'.

(b) *Category B environment (see Clause 1.3.6.2)* Category B environments include general fabrication activities, large workpieces, steel building structures, inside pressure vessels, processing tanks, storage tanks, conductive confined spaces and onboard ships.

NOTES:

1 AS 3195 and IEC 60974-1 classify Category B environments as 'environment with increased hazard of electric shock'.

2 When the weather is hot, when high preheat temperature is employed or when the vessel is exposed to the sun, many Category B environments become Category C environments.

(c) *Category C environment (see Clause 1.3.6.3)* Category C environments include coffer dams, trenches, mines, in rain, underwater, partially submerged areas, splash zones (see also Appendix B).

NOTE: It may be possible to derate Category B and Category C environments, where adequate effective precautions are taken to reduce or eliminate the risk (e.g., airconditioning, special insulating clothing).

Extract 5

3.2.6 Maximum open-circuit voltage

Except as provided for in Clauses 3.2.7 and 3.2.8, the maximum open-circuit voltage shall not exceed the values specified in Table 3.2.6.

TABLE 3.2.6

MAXIMUM PERMITTED OPEN CIRCUIT VOLTAGE

Working conditions	Maximum permitted open circuit voltage
Category A environment (Clause 5.1(a))	d.c. 113 V peak, or a.c. 113 V peak and 80 V rms
Category B environment (Clauses 1.3.8.1 and 5.1(b))	d.c. 113 V peak, or a.c. 68 V peak and 48 V rms
Category C environment (Clauses 1.3.8.2 and 5.1(c))	d.c. 35 V peak, or a.c. 35 V peak and 25 V rms
Mechanically held torches with increased protection for the operator	d.c. 141 V peak, or a.c. 141 V peak and 100 V rms
Plasma cutting	d.c. 500 V peak

NOTES:

1 Each power source, complying with IEC 60974-1, that is suitable for a Category B environment should be marked with a symbol comprising the letter 'S' in a square box. This symbol can be found in Box 7 of the rating plate or sometimes on the front panel.

2 MMAW power sources to old Standards may supply excessively high a.c. voltages for Category B and Category C environments. It is necessary to measure the open-circuit voltage to determine suitability and, if necessary, fit a hazard-reduction device.

3 Power sources to be used in Category C environments are likely to require a hazard-reducing device (see Clauses 2.3.3 and 3.2.7).

Extract 6

3.2.7 Hazard-reducing devices

3.2.7.1 *General*

Hazard-reducing devices shall reduce electrical-shock hazards originating from no-load voltages that exceed the values in Table 3.2.6

Where the unreduced no-load voltage cannot exceed 113 V peak for d.c. output welding machines, the hazard reducing device shall operate within 0.5 s and, where the unreduced no-load voltage cannot exceed 113 V peak or 80 V rms for a.c. output welding machines, the hazard reducing device shall operate within 0.3 s.

Where the unreduced no-load voltage may exceed d.c. 113 V peak or a.c. 80 V rms, the hazard-reducing device shall operate within 0.3 s.

Conformity shall be checked by measuring the time between interruption of the welding current and completed operation of the hazard-reducing device.

It shall not be possible to remove any hazard-reducing device, without the use of a tool.

Proper functioning of hazard-reducing devices shall not be affected by interference from remote controls, arc-striking devices or arc-stabilizing devices of the welding power source (that is, limits for no-load voltage shall not be exceeded).

3.2.7.2 *Voltage-reducing devices*

Voltage-reducing devices shall automatically reduce the rated no-load voltages to which they are connected to less than d.c. 35 V peak or a.c. 25 V rms, at a maximum resistance of the external welding circuit being 200 Ω.

In the event of failure, voltage-reducing devices should fail to a safe condition within 1 s.

NOTE: The rated no load voltage specified above is considerably less than that specified by IEC 60974-1.

Extract 7

3.2.7.3 *Hand-piece trigger switches*

Where a hand-piece trigger switch that operates a solenoid switch in the welding circuit is used as a hazard-reducing device—

(a) the voltage of its control circuit shall be not more than d.c. 35 V peak or a.c. 25 V rms; and

(b) its switching mechanism shall—

(i) return to the off position, immediately the welder releases pressure on the switch;

(ii) be easy to hold in the closed position, enabling the welder to carry out normal welding operations, without muscle strain;

(iii) have a two-stage operation to move to the on position, so that there is a low probability of accidental closure of the switch during any hazardous operations (for example, changing electrodes); and

(iv) automatically latch in the off position, on release of pressure by the welder.

3.2.7.4 *Indication of satisfactory operation of voltage-reducing devices*

Each voltage-reducing device shall be provided with a reliable device that indicates that is operating satisfactorily. Where a lamp is used, it shall light when the voltage has been reduced.

3.2.8 Ancillary devices

The welding power source cabinet may contain additional equipment, which may be separate devices, such as a high-frequency arc-initiating device, a smoke removal device, a wire feeder or a water cooler. If these devices are used, they should be made to appropriate Standards, such as the IEC 60974 series of Standards.

Any additional equipment shall be connected to the power source in accordance with the manufacturer's recommendations. They shall either have their own isolation switches or be isolated by the power source switch.

Users should be made aware that high-frequency arc-starting devices deliver up to 6500 V at a current up to 100 mA, which is imposed over the welding current. It can give a severe and painful electric shock. It may cause damage to electronic devices, such as heart pacemakers, computers, electrical meters in the vicinity, even if they are not directly connected to the same power supply.

Where it is necessary to earth any conductor of a high-frequency circuit, the earthing connection shall be made to an earthing electrode driven into the ground and not under any circumstances in contact with water or gas pipes or a building structure. The earthing conductor to an earthing electrode shall have a cross-sectional area of not less than 2.5 mm^2, be of stranded copper and be insulated with not less than 250 V grade insulation. The earthing electrode and its connections shall be effectively shielded from personal contact. (See also Figure 3.2.8 and AS/NZS 3000.)

Any power source fitted with high-frequency arc-initiating equipment shall carry a warning in a prominent position stating the following:

HIGH-FREQUENCY EQUIPMENT IS INSTALLED

VOLTAGES UP TO 6500 V MAY BE PRESENT WITHIN THE CABINET

DISCONNECT FROM POWER SUPPLY BEFORE REMOVING COVERS

Appendix B – Record of results of tests

Company Name:				
Description of VRD :				
Model No. :			**Date of Test:**	
Serial No. :				
Test Parameter	**Procedure Reference**	**Measured value**	**Required Value Seconds Max.**	**Compliance**
Maximum Permitted Open-Circuit Voltage			35 Volts Peak 25 Volts rms	
Maximum circuit resistance			200 Ohms Maximum	
Time to operate			0.3 secs (a.c.) 0.5 secs (d.c.)	
Test equipment used:				
Name of testing officer:				
Signature:				

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NDNP TECHNOLOGY DIFFUSION ACTIVITY # 27	ABN 69 003 696 526 **NATIONAL DIFFUSION NETWORKS PROJECT** **TECHNOLOGY QUESTIONNAIRE** **Mining Industry Group** **Voltage Reducing Devices – Pre-Start and Routine Performance Verification Checks**	**Document No:** 9.4.6 – QR - 003 **Revision No:** Rev 0 **Page 1 of 2** **Date:** 21 Nov 2005

As part of the WTIA National Diffusion Networks Project the Mining Industry Sector has identified the need to be able to check the operation of the voltage reducing device (VRD) on a MMA welding machine. The WTIA has prepared a note "Voltage Reducing Devices – Pre-Start and Routine Performance Verification Checks" that explains how to carry out this check. As a valued technology expert in this area we would like you to be part of the Technology Expert Group to review this document. Please complete this questionnaire so we can gauge the success of meeting this need.

Objective 1: Identify the need to be able to check functionality of VRD

Queries have been received from the various mines asking how to check whether the VRC is working properly. This document explains the operation of a VRD and how to check its operation. How well does the document achieve these aims?

poor ☐ average ☐ good ☐ very good ☐

Comments: _____

Objective 2: Identify appropriate technology receptors

This document was written for Electricians, Welders, Welding Supervisors and Maintenance Managers in the mining Industry. 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 current best practice for checking operation of VRD's

The document was written to reflect current best practice for checking the operation of VRD's. Do you envisage opportunities for the use of this practice in 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? _____

Objective 5: Broad dissemination of technology to the Mining Industry

Please indicate how best to disseminate this poster to the appropriate Industry Recipients

Free Website Download ☐ Poster☐ Pocket Guide ☐ Pamphlet ☐

If poster, what size? A1 ☐ A2☐ A3 ☐ Laminated ☐ What selling price? $

Any other format for the information? _____

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Objective 6: Continuous Improvement

Please Identify areas where the document can be improved or return the document with your recommended additions/amendments. Alternatively, please use the area below to provide any additional comments.

*Respondents Name:*_____ *Company:* _____ *Phone:* _____

Fax: _____ *Email:* _____ *Date:* _____

Please Fax (02 9748 2858) or E-mail (j.baker@wtia.com.au) your response.

Your prompt response is appreciated.