Detailed Research Report

WORLD WIDE ELECTRICAL SAFETY TECHNOLOGY

15 June 2023

Approval of HRE/RVT Technology to AS/NZS 3000:2018

Standards Australia

On 28 April 2023, World Wide Electrical Safety Technology Pty Ltd (WWEST) submitted a proposal to Standards Australia regarding the WWEST technology solution, utilising High Resistive Earthing (HRE) / Residual Voltage Technology (RVT).

At a meeting with Standards Australia on 5 May 2023, Standards Australia recommended WWEST submit the proposal, using the Standards Australia online Portal, for review by the (AS/NZS 3000:2018) EL-001 Committee.

On 8 May 2023, WWEST commenced the online process of Submitting a Proposal to Standards Australia.

NSW Department of Fair Trading

On 19 May 2023, WWEST was advised by the NSW Department of Fair Trading that the RVT complies with all Standards requirements as certified to AS/NZS 3000:2018 (May 2019), as a non-declared article with CS Number 10890N.

Wayne Callen
Director, World Wide Electrical Safety Technology Pty Ltd
E: wayne@wwest.com.au M: 0488 125 546
www.wwest.com.au

Renewables are Compromising the Safety and Reliability of the Distribution Grid

(FINAL SUB-CIRCUIT PROTECTION REVIEW)

Presented to Standards Australia on 5th May 2023

Authors

Wayne Callen
Director, Research & Development
Email: wayne@wwest.com.au Mobile: +61 488 125 546

Allan Edwards
Director, Business Development
Email: allan@wwest.com.au Mobile: +61 488 068 009

Independent Engineering Design & Review

Paul Malanchuk
Director, Electrical Projects Australia

Email: paul@electricalprojectsaustralia.com.au Phone: +61 249 675 999

Jonathan Carroll
Director, Engineering Manager
Email: jonathan@electricalprojectsaustralia.com Phone: +61 249 675 999

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Definitions

- Basic Safety - protection by insulation, out of reach, obstacles and barriers *(Rapid isolation is additional protection).*
- BS - British Standards.
- Cascading - stepping down of protection i.e., circuit breakers and fuses from HV/MV/LV,
- Circulating Fault Current – Fault current path Refer to Figure F2 on Page 15,
- Copper Pipe bonding- creates a 2nd MEN Point and enables DC Voltage Rise and Circulating Current on extraneous metal parts,
- Class II – reinforced insulation as a protection method *(fundamental protection principle),*
- Cumulative impact – the mathematical sum of leakage currents that can add up to dangerous levels,
- Earthing Systems;
    i. *IT- Isolated Earthing- the use of isolation as a protection method (IEC 60634 series),*
    ii. *TT- Earth-Earth- the use of Earth and Earth as a protection method,*
    iii. *TN- Earth and Neutral- the use of earth and neutral as a protection method,*
- Electrolysis - *(Corrosion of Dissimilar Metals). 2 metals joined in a manner (water and EMC) to conduct DC current. (Refer Photo 4),*
- EMC – Electro Magnetic Compatibility- Appliance Leakage current to earth (5mA typical) refer Page 10,
- Fundamental Principles - Protection Against electric shock, Danger and Damage (fire), Control and Isolation. *(**AS/NZS 3000:2018 Clause 1.5**)*,
- HRE - HIGH RESISTIVE EARTHING – Enables a Voltage Detection Method (RVT) in Island Mode,
- Island Mode – Reinforced Insulation, No conductive copper or Equi-potential Bonding to Protective Earth *(True Earth- Drawing A & A01),*
- Lightning Protection – Protection Provided by Final Sub-Circuit Isolation *(Island Mode). No damage to appliances at final sub-circuit (no PE),*
- Localising The Fault – Isolating a Fault to a Specific Circuit & Eliminating Cascading and 10 dangerous fault conditions. *(Drawing A),*
- MEN HRE – Soil Impedance Between Earth Stakes *(Earth Fault Path- Drawing A & A01),*
- NCC – National Construction Codes
- Protective Earth – Low impedance earthing method *(Part of the MEN).*
- PV Solar Fires – DC Thermal Runaway *(Refer Photo 3),*
- RVT-VMD – Residual Voltage Technology- Voltage Monitoring Device,
- Segregation – The Separation of Extra Low 12V DC & Low Voltage 240V AC,
- Soil Resistivity – The Measure of Soil's Capability to Oppose, Resist & Reduce the Flow of Electric Current. *(Drawing A & A01),*
- TN-C - Protective Earth Neutral *(PEN - HRE);*
    i. *Cascading protection method,*
    ii. *At Point of Entry, is a 2 wire Class II Arrangement (Isolated Earthing),*
    iii. *The Utility Supply Zone (Sealed Metering Yellow Zone).*
- TN-C-S Zone - Customer Zone - Basic Safety or Basic Protection. *(Red Zone),*
- TN-C-S –MEN– The 10 Dangerous Faults Are Upstream of the Toroidal Coil *(Utility Zone – Refer Drawing A)*,
- Type AC RCD- The specified tripping current of 30mA and isolation time of 40mSec,
- Voltage Rise – An Increase in Voltage on the Protective Earth Potential Difference Between N & E.

Descriptions

- EV Charging Stations – All electric vehicles are manufactured overseas where protective earthing systems are inconsistent with Australian Standards. Tesla EV are designed in the US for a TT Earthing System. There is a compatibility issue with British Standards (BS 7671) where use of TN-C-S is Banned on external charging stations,

- EV Charging Circuits - in Class 2 Buildings (High Density) represents a major safety risk for the following reasons;
  i. *Car park spacing – needs to be 1200mm between electrified exposed metal parts,*
  ii. *Weight - 2-3 times heavier than Internal Combustion vehicles,*
  iii. *Ventilation – Gases (Hydrogen) emitted whilst charging,*
  iv. *Thermal Runaway – Lithium Batteries (well documented),*
  v. *Cumulative Impact – power consumption of multiple units (100-200 units),*

- Verification Panel – A Test Panel Used to Verify the 10 Dangerous Fault Types of the MEN Earthing System, and the benefits of RVT-HRE in a Real-World Situation *(Refer Page 17),*

- Type A RCD - is a combination of AC function as specified leakage current of 30mA and isolation time of 40mSec and a DC function with a specified leakage current of 43mA and isolation time of up to 300mSec to detect up to 6mA of Ripple DC. The outcome of these functions requires separate testing, which is not available in most test equipment,

- RCD/RVT is a combination of a Type A RCD as specified above and RVT as specified on P15, 10mA and 30mSec with both (AC/DC Smooth) Current and Voltage Leakage having separate test functions. Standard existing Test equipment is suitable for use in validation requirements.

- The EMC Leakage of appliances is well documented and surprisingly significant whereby a domestic dwelling might typically expect to see 30mA or more of leakage at evening peak domestic usage time see EMC Chart. The MEN Earthing System, when applied to a Residential Street or a Class 2 High Density Residential Building with up to 200 Domestic Dwellings, might expect to see more than 3000mA of leakage of DC Current on the Protective Earth. Whilst under normal conditions these leakages will dissipate through the earthing system and are not considered dangerous. However, under a 'perfect storm fault' scenario the Cumulative Impact of Earth Leakages at this level are very dangerous and can be catastrophic.

- Electrolysis - 2 different metals joined to allow conduction, water & different potential resulting in corrosion. Copper and iron (2 dissimilar metals) when connected as earth rods form a galvanic cell with a potential difference of approx. 0.7V when connected via the neutral conductor. Under the right conditions, a continuous corrosion current as high as 35mA can flow, causing electrolysis and corrosion to occur.

Executive Summary

Renewables are Compromising the Safety and Reliability of the Distribution Grid

(FINAL SUB-CIRCUIT PROTECTION REVIEW)

The provision of the Electrical Distribution Supply (Grid) is changing dramatically and for many, **electrical safety is now compromised, with lives potentially placed at risk.** The Installation Standard, AS/NZS 3000:2018, needs to reflect these changes as **electrical safety has reached a tipping point** due to the following critical issues. These are further shown in our Technical Papers & Videos, via the **QR code** link on pages 3 & 4.

i. The **Transition to Renewable Energy** (e.g., PV Solar and Battery Storage) has **disrupted the integrity and reliability** of the existing Electrical Distribution Grid due to the incompatibility of AC and DC Earthing systems, resulting in increased fire and electrical safety incidents,

ii. A **Dangerous situation** exists where **Jurisdictional Responsibility** between **Standards Organisations** is unclear with conflicting Standards **AS/NZS 3000:2018, AS/NZS 3012:2019 and AS/NZS 5033:2021** having inconsistencies, causing a lack of clarity for installers, resulting in an increased risk of electric shock, electrocution, and fire. **The TN-C earthing method is not suitable for the Transition to Renewables.**

iii. **Changes to National Construction Codes and Plumbing Standards** (for safety reasons), have resulted in a forced permanent shift in the electrical **earthing landscape** which is not reflected in **AS/NZS 3000:2018 Part 2** causing the **underlying basic safety principles to be compromised,**

iv. **Safety Switches (RCD's) & strategies are now impotent in providing protection** against the 10 dangerous fault types. The **TN-C-S earthing system** is banned for use with external **EV Charging Stations** in the **UK (BS7671 Section 722.411.4.1) but deemed acceptable in Australia as per AS/NZS 3000:2018.**

v. The recently mandated change from 'Type AC' to 'Type A**' RCD's will not result in effective or improved electrical safety outcomes while ever the underlying earthing issue remains unresolved.** 'Type A' only provides protection for Ripple DC but not Smooth DC (PV Solar and Battery Storage) Supplies. Validation of 'Type A' RCD's for DC Fault component requires more sophisticated test equipment than commonly used and changes to the specifications of **AS/NZS 3000:2018**.

Recommendations and Solutions

i. **Deletion of AS/NZS 3000:2018 Clause 5.1.4, Example 3.** Historical circumstances of wiring and main switchboards make older installations unsuitable for the Transition to Renewables. This is critical for the safety of individuals with outdated earthing and RCD's ineffective and dangerous when installed with PV Solar, Battery Storage Systems and EV charging stations.

ii. Deletion of **Example 3** will not affect **AS/NZS 3000:2018** but will affect **AS/NZS 5033:2021** - The Installation of PV Solar, is a major electrical upgrade and requires updating of Earthing Protection to current standards.

iii. The **Residual Voltage Technology (RCD/RVT) with HRE (High Resistive Earth), will enable a smoother transition for renewables using a simple and proven engineered solution,** mitigating the risks associated with the 10 identified major fault conditions. This development in technology will lower transition costs (no rewiring) and allow increased efficiency outcomes.

iv. The simple Restructuring of the Protective Earth (PE) at the final sub-circuit and installation of the RVT (Voltage detection device) provides the ultimate solution and is cost-effective and comparative with current devices such as 'Type A' RCD and Arc Flash devices.

The **RVT when combined with an RCD & utilising an HRE at the final sub-circuit, represents the biggest advance in electrical safety since the introduction of the RCD,** & will **significantly improve safety** & reduce the risk of another Denishar Woods ***(Denishar Woods Vs WA Govt & others)*** tragic incident from ever occurring again.

Abstract

The existing **TN-C-S MEN Low Impedance Earthing System** for end-user **Final Sub-Circuits is Compromised**, placing Individuals' **Safety at Risk from Electric Shock and Fire**. The impact of **NCC** (National Construction Codes) and **BCA** (Building Code of Australia) changes, **Outdated Standards**, the uptake of **Renewables and Energy Micro Grids** together with the **Incompatibility of Earthing Systems** (TN-C and TN-C-S MEN) has caused a **Breakdown of Basic Safety Principles.**

Adoption of a Proven Engineered Solution **(RVT-HRE)** which addresses the Breakdown of Basic Safety Principles and underlying Earthing issues, mitigates the risks of electric shock and fire, while requiring little change or expense. The **RVT-HRE** methodology can be used in all earthing arrangements globally, as per **IEC 60364 Standard series**. The **RVT-HRE** technology works on both **AC & DC earthing systems** and eliminates the **10 existing electrical faults** of the TN-C-S Earthing System**.** This technology **must be endorsed.**

"*In all my electrical experience I have not seen an electrical safety protective device that operates on the same principles or as effectively as the ….. device. The ... device tripping is very fast and actuates with a time delay that is shorter than any other safety device ..."* **(Trevor Blackburn, Associate Professor, School of Electrical Engineering, University of New South Wales).**

"Where it is possible to safe-guard against a foreseeable risk, which…… by adopting a means, which involves little difficulty or expense, the failure to adopt such means will in general be negligent." (**Chief Justice Sir Harry Gibbs, Turner Vs The State of South Australia (1982) High Court of Australia**).

Videos & Supporting Technical Papers

Technical Drawings – Video Explanation

1. **Drawing A** - Final Subcircuit Arrangement within a Multiple Earth Neutral (M.E.N.) System of Earthing.
2. **Drawing A1** - Alternative Final Sub-Circuits Within an M.E.N. Utilising RVT-HRE.
3. **Drawing A01** - M.E.N. 3 Phase Supply Distribution (Protective Earthing) & RVT-HRE.
4. **Drawing A03** - M.E.N. 3 Phase Supply Distribution (Protective Earthing) & RVT-HRE & P.S.O.A (Portable Socket outlet Assembly).

Corporate Videos

1. **How WWEST Started.**
2. **Welcome to WWEST.**
3. **Instructional –** *With Subtitles.*
4. **Industry Applications.**

WWEST – Videos Available At This Link

www.youtube.com/channel/UCy5kbI93VDNjaDCkt3X_Wmw

or

QR Video Link:

Scan QR code below with your phone camera.

Technical Papers & Drawings

1. **WWEST Research Paper (May 2023), –** Renewables Are Compromising the Safety & Reliability of The Distribution Grid.
2. **WWEST Technical Drawings – (A, A1, A2, A2EV, A01, A02,A03, A04,A05,A06)**
   - ***Drawing A -*** *Final Subcircuit Arrangement within a Multiple Earth Neutral (M.E.N.) System of Earthing.*
   - ***Drawing A1 -*** *Alternative Final Sub-Circuits Within an M.E.N. Utilising RVT-HRE.*
   - ***Drawing A01 -*** *(M.E.N.) System 3 Phase Supply Distribution (Protective Earthing) & RVT-HRE of Earthing, Utilising RVT-HRE.*
   - ***Drawing A2 -*** *Alternative Final Sub-Circuit Arrangement Within an M.E.N. Utilising Functional Earthing (FE) EV Charging Circuits.*
   - ***Drawing A2 EV*** *- Alternative Final Sub-Circuit Arrangement Within an M.E.N. Utilising Functional Earthing (FE) EV Charging Circuits.*
   - ***Drawing A02*** *- Final Subcircuit Arrangement within a Multiple Earth Neutral (M.E.N.) System of Earthing, Utilising RVT-HRE.*
   - ***Drawing A03*** *– M.E.N. 3 Phase Supply Distribution (Protective Earthing) & RVT-HRE & P.S.O.A (Portable Socket outlet Assembly).*
   - ***Drawing A04*** *- TN Earthing Diagrams.*
   - ***Drawing A05*** *- 3 PH Star Distribution System*
   - ***Drawing A06*** *- 3 PH Star Distribution System Showing Example Voltage & Current Neutral Rise*
3. **Paul Malanchuk (Director) Electrical Projects Australia**
   - Independent Review of WWEST RVT-VMD Technology (Dec 2022).
4. **Jonathan Carrol –** Final Sub Circuit Drawing A.
5. **Jonathan Carrol –** Final Sub Circuit Drawing A01.
6. **Sam Dib – BE MIE Aust C.Eng. NER RPEQ (3495475)** - PSOA Independent Review 18 March 2021.
7. **Geoff Cronshaw (Chief Electrical Engineer at IET) -** BS 7671 Amendment 1 (2018).
8. **AUSTEST Compliance Testing Final Report –** 31 May 2019, Residual Voltage Technology (RVT).
9. **NSW Fair Trading –** CS Certification NSW CS10890N.
10. **Taylor Callen – Thesis Paper** - "Earthing Systems in Relationship to the Characteristics of Protection Devices."
11. **Trevor Blackburn, Associate Professor UNSW School of Electrical Engineering & Telecoms** "RVD White Paper, Alternative Earthing Method, (Protecelec Sept. 2004)"
12. **Trevor Blackburn, Associate Professor UNSW School of Electrical –** Letter to Protecelec Sept. 2005
13. **Craig Tickner –** Mt Owen Coal Washery Case Study.

All Technical Papers Available At This Link

https://1drv.ms/f/s!ArjfSWHO80k1yDXMB50ASObZBAzN?e=fMK442

or

QR Video Link:

Scan QR code below with your phone camera.

Renewables are Compromising the Safety and Reliability of the Distribution Grid

(FINAL SUB-CIRCUIT PROTECTION REVIEW)

Urgent Revision of AS/NZS 3000: 2018 Section 5 Earthing Arrangements

For many years, there has been multiple factors which have **'eroded'** the integrity of the existing grid **TN-C DISTRIBUTION EARTHING SYSTEM (PEN)** a **HIGH RESISTIVE EARTHING SYSTEM (HRE) -** *refer page 6.*

The **Transition to Renewable Energy,** sources such as Micro-grids PV Solar, EV charging stations, Wind, Wave, Hydro and Battery Storage systems has disrupted the reliability of the existing Grid system due to issues such as **DC Voltage Rise, Synchronization, Circulating currents and Earthing compatibility issues**.

These factors have led to **a significant decline in basic safety principles** and subsequent increase in electrical protection failures, critical for the safety and well-being of individuals. **Drawing A** attached, lists **10 dangerous fault types** where the **majority of these faults emanate from the TN-C zone (Yellow Zone).**

The TN-C-S MEN EARTHING SYSTEM- A LOW IMPEDANCE EARTHING SYSTEM (as shown in **Drawing A** as the **Red Zone on Page 12**), as stated in AS/NZS 3000: 2018 Clause 5.1.2, must *'provide an effective and reliable low impedance fault path',* but due to evolutionary change and technological developments is ***no longer 'fit for purpose'*** in its current form. **The escalation of risk of electric shock and fire within the TN-C-S MEN low impedance earthing landscape is significant and well documented.** More than 2 solar fires are reported per day in Australia with the state of NSW alone reported 2-3 fires per week in 2021 (Australian Bureau of Statistics). These fires are a result of a failure in the protective earthing system as per Part 1 of AS/NZS 3000:2018.

The Transition to Renewables - PV Solar, EV Charging Stations, Wind, Wave, Hydro and Battery Storage systems and the resultant impact of **'DC' Voltage leakage to the Distribution Grid** together with ageing infrastructure and mandated changes to **National Construction Codes (NCC), and Plumbing Standards**, have resulted in a forced permanent shift in the **Electrical Earthing Landscape** which has given rise to a new phenomenon called **Island Mode**.

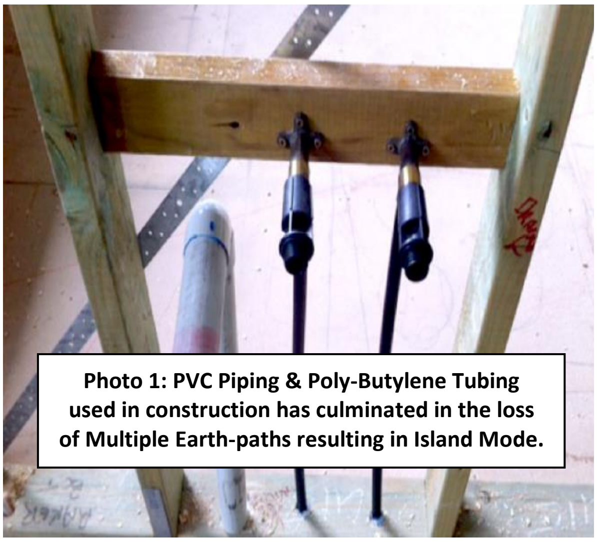


Photo 1: PVC Piping & Poly-Butylene Tubing used in construction has culminated in the loss of Multiple Earth-paths resulting in Island Mode.

The impact of Island Mode is significant whereby the Multiple Earthing points in a building are no longer present as stated in **AS/NZS 3000: 2018 Appendix E;**
ELECTRICAL INSTALLATION REQUIREMENTS IN NATIONAL CONSTRUCTION CODES (NCC).

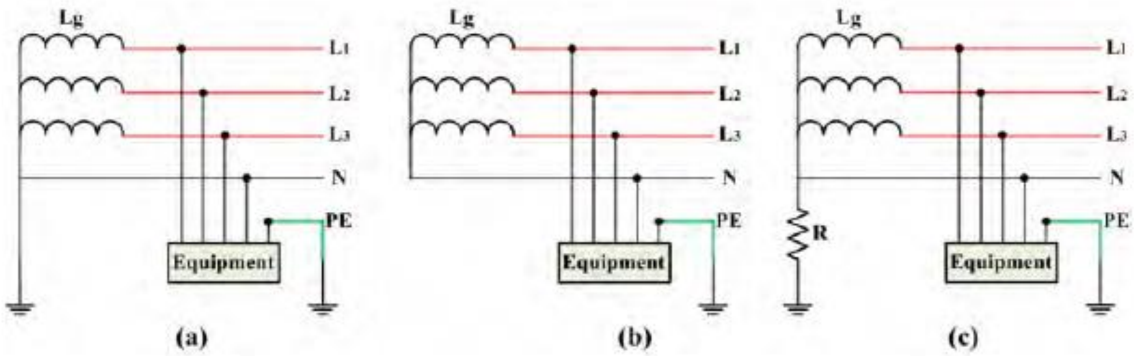
This Standard contains provisions relating to the protection of an electrical installation from fire and electric shock, which are dependent on, or incorporated in, building requirements. National Construction Codes also contain several other provisions which relate to the design, selection and installation of equipment that forms part of an electrical installation, and which are intended to satisfy objectives for safety, health, amenity, sustainability and energy efficiency.

High Resistive Earthing (HRE)

Isolation is a protective method outlined in the **IEC 60364 Standard series**. It is a part of the 3 families of grounding arrangements as IT (Isolated Terra) in a low voltage AC Grid System.
The 3 grounding (earthing) arrangements are;

i. *IT Earthing System*
ii. *TN Earthing System*
iii. *TT Earthing System*

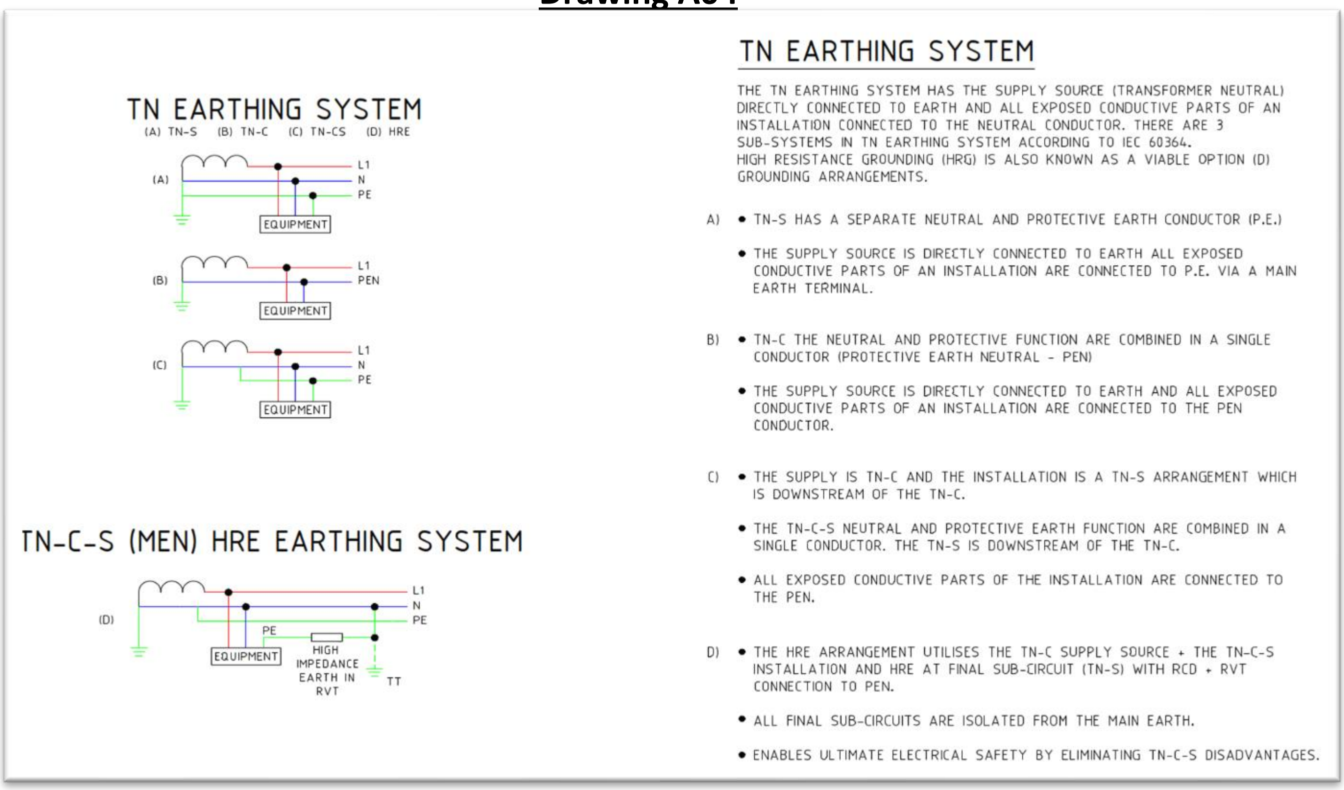
AS/NZS 3000:2018 – Clause 5.1.4 Example 5 *"Electrical installations complying with IEC 60364 series which permits the use of TN, TT and IT systems as alternatives to the MEN system. According to IEC 60364 Standard, there are 3 families of grounding arrangements in low voltage AC grid systems. High Resistance Grounding (HRG/HRE) is also known as a viable option. HRE is a possible solution to reduce overvoltage stress without losing the advantages of an IT network is connected to the transformer neutral. The resistance is selected in such a way that the earth fault current is limited resulting in elimination of Arc Flash hazards".*



AC Grid Grounding System: (a) TT, (b) IT and (c) High Resistance Earth (HRE)

High Resistance Earthing (HRE) is a variant of **TT** as shown above. **Drawing A04 & Notes** below defines the **HRE** Earthing System in a **TN** Earthing Arrangement. The **HRE** methodology can be used in all earthing arrangements globally, as per **IEC 60364 Standard series**. The **RVT-HRE** technology works on both **AC & DC earthing systems** and eliminates the **10 existing electrical faults** of the TN-C-S Earthing System**.** This technology **must be endorsed.**

Drawing A04



Impacting Reference Documents & Standards


Photo 2: Island Mode.

The multiple earthing points as shown in **Drawing A *(on Page 12, in Red Zone)***, are critical to the MEN system, **no** longer exist within all final sub-circuits in residential, commercial, and industrial buildings **due to the elimination of copper piping,** (water and gas) being replaced with **non-conductive PVC piping & Poly-Butylene tubing.** Additional **mandatory wet area waterproofing** requirements and increased use of **Class II appliances** only exacerbate the problem.
These legislated changes, developed and subsequently mandated in the **NATIONAL CONSTRUCTION CODES (NCC)**, have effectively been in place since the mid ninety's and are now reflected in every new dwelling and building and together with earthing degradation/aging infrastructure issues, has meant that the MEN and the **underlying Basic Safety Principles, are compromised.** These fundamental issues need to be addressed urgently to ensure that **AS/NZS 3000**:**2018** is up to date with other jurisdictions' mandatory requirements and relevant technological developments in the NCC.

A Dangerous situation exists where jurisdictional responsibility between Standards Organisations is unclear with conflicting Standards **AS/NZS 3000:2018, AS/NZS 3012:2019 and AS/NZS 5033:2021** causing inconsistencies and lacking clarity for installers, resulting in increased risk of electric shock, electrocution, fire and Jurisdictional Error. If these Differences remain unresolved, it is likely that more electric fires, electric shocks, and electrocutions could result from the outdated earthing methods and multiple technical issues outlined, including fuses and circuit breakers, copper piping bonding (2nd MEN), and the use of PV Solar, Battery Storage, DC Current Leakage and use of Electronic Inverters.

'DC' Voltage Rise


Photo 3: Thermal Runaway.

DC Voltage-rise and Harmonics on the network supply systems caused by renewable energy sources such as PV Solar, Wind, Wave, Hydro and Battery Storage systems and the **cumulative effect of increased use of electronic transformers** (Pulse Width Modulation) can cause high neutral voltage fluctuations due to the common mode voltage generated by the active front end converters. It is mandatory that all electrical equipment sold in Australia needs to have **Electro-Magnetic Compatibility (EMC)** individually to a maximum leakage of 5mA per appliance.

Photo 3 shows high levels of radiation corrosion (Ionising) 'DC' electrolysis and Solar fires are the result of DC Voltage Rise (thermal runaway).


Photo 4: EMC Degradation of galvanised steel in a switchboard.

This is not rust but the effects of **Electro-Magnetic Radiation (EMR)** voltage rise caused by a breakdown of the protection earth system. However, ageing equipment considerations, the cumulative impact of equipment and appliance leakages, can result in **circulating fault currents** of more than 30 *mA* **(Photo 4)**. The TN-C has a degraded EMC performance compared to the TN-S. The EMC Impact table is an example of the cumulative impact of how mathematically a small leakage current can add up to dangerous levels.

There are other factors which need to be considered whereby one of the 10 dangerous faults, ageing infrastructure, the age of housing/units, ageing appliances and a faulty appliance. These factors combined would lead to a similar event to the Grenfell Tower scenario- a 'perfect Storm' event.

Final sub-circuit HRE localizes the fault and does not allow the leakage to accumulate or any of the 10 dangerous faults to arise.

RCD Functionality

RCD's cannot distinguish between load current and fault current upstream of the toroidal coil while-ever the underlying earthing issue of segregation between extra low and low voltage exposure, remains unresolved. The 'DC' voltage rise on the PE has resulted in the mandated change from a 'Type AC' to a **'Type A' RCD** to deal with the 'DC' current component, present on the earthing system will not result in effective or improved electrical safety outcomes.

'Type A' RCD's will not provide protection on Smooth DC outputs which are typically supplied by Renewables (PV Solar and Battery Storage). A **'**Type A' RCD can only detect up to 6mA of Ripple DC, anything above this level creates a magnetic effect and makes the RCD ineffective.

In the UK, the use of 'Type A' RCD's has resulted in BS7671 making specification changes from 30mA to 43mA and 40mSec to 300mSec together with additional costs for Electrician's test equipment to accommodate this change.

EMC Typical Equipment Maximum Earth Leakage Values

British Standards (BS) EN 60335-1, provides the general safety requirements for household and similar electrical appliances. Maximum values of earth leakage for appliances are identified below, it is important to remember these are maximum values:
For class II appliances and for parts of class II construction - 0.25 mA.
For class 0, 0I and III appliances: 0.5 mA b for class I portable appliances -, 0.75 mA.
For class I fixed motor-operated appliances - 3.5 mA.
For class I fixed heating appliances - 0.75 mA or 0.75 mA/kW of rated power, with a maximum of 5 mA, whichever is the higher.

The amount of leakage current will vary according to the type of equipment. The **IEC 60335** series of Standards provides requirements for different types of products:

- *Fixed PC workstation - 2 mA*
- *Printer - 1 mA*
- *Photocopier - 1.5 mA*
- *Laptop - 0.5 mA (with EMC filter)*
- *Grills, toasters/portable cooking appliances - 0.75 mA (earthed metal)*
- *Fridges - 1.5 mA (class I)*
- *Dishwasher - 5 mA*
- *Hobs, ovens - 1 mA or 1 mA/kW of rated power*
- *Washing machine - 5 mA*
- *Tumble dryer – 5 mA*
- *Electric heat pumps - 10 mA (accessible to public)*
- *Floor heating - 0.75 mA or 0.75 mA/kW of rated power.*

Luminaires can also be a source of leakage current; ***BS EN 60598-1*** *provides the leakage current requirements for Luminaires:*

- *Continuous interference - 0.5 mA*
- *Class 0 and Class II -1 mA*
- *Portable, Class I - 1 mA*
- *Fixed Class I up to 1 kVA of rated power, Increasing in steps of 1 mA/kVA up to a maximum of 5mA.*

Electro Magnetic Compatibility - Leakage Values

Household Appliance Leakage Values mA			
Fridge	1	Dishwasher	5
Stove Cooktop (Hobbs)	5	Oven	5
Washing machine	5	Tumble Dryer	5
Electric heat pumps	10	Floor heating	0.75
Fixed PC workstation	2	TV- Audio System	1
Electric Grills	0.75	Laptop	0.5
Portable cooking appliances	0.75	Toaster	0.75
Photocopier	1.5	Home Printer	1

EMC – Cumulative Impact

Comparison showing the Cumulative Impact of EMC (DC Voltage) when Multiple Appliance (Highlighted) are used at Dinner Time in Conventional TN-C-S MEN, with HRE at Final Sub-circuit.

TN-C-S MEN Earthing Arrangement	Household Type	BCA Category	Cumulative Potential mA
Conventional Low Impedance	Single Dwelling	Class 1	30.75mA
	20 House Sub-division	Class 1	615mA
	100 Units High Density	Class 2	3075mA
Using HRE at Final Sub-circuit	Single Dwelling	Class 1	Nil
	20 House Sub-division	Class 1	Nil
	100 Units High Density	Class 2	Nil

Risk Key	Extreme	High	Medium	Low

EMC – Findings

The increase in the Levels of DC Leakage present in modern day electronic appliances in a typical household is surprising and if one of the identified fault conditions occurs, could represent an extremely dangerous situation.

The EMC Leakage of appliances is well documented and surprisingly significant whereby a domestic dwelling might typically expect to see 30mA or more of leakage at evening peak domestic usage time see EMC Chart. The MEN Earthing System, when applied to a Residential Street or a Class 2 High Density Residential Building with up to 200 Domestic Dwellings, might expect to see more than 3000mA of leakage of DC Current on the Protective Earth. Whilst under normal conditions these leakages will dissipate through the earthing system and are not considered dangerous. However, under a 'perfect storm fault' scenario the Cumulative Impact of Earth Leakages at this level are very dangerous and can be catastrophic.

A level of 80mA is regarded as Lethal as per the chart, a Conventional TN-C-S MEN installation is far more dangerous than an installation using HRE at Final Sub-circuit where the risk is low, with individuals not exposed to any potential Voltage Rise or Fault condition.

EV Charging

EV Charging Stations – All electric vehicles are manufactured overseas where protective earthing systems are inconsistent with Australian Standards. Tesla EV are designed in the US for a TT Earthing System. There is a compatibility issue with British Standards (BS 7671) where use of TN-C-S is Banned on external charging stations.

EV Charging Circuits- in Class 2 Buildings (High Density) represents a major safety risk;

- *Car park spacing – needs to be 1200mm between electrified exposed metal parts,*
- *Weight - 2-3 times heavier than Internal Combustion vehicles,*
- *Ventilation – Gases (Hydrogen) emitted whilst charging,*
- *Thermal Runaway – Lithium Batteries (well documented),*
- *Cumulative Impact – power consumption of multiple units (100-200 units).*

Clauses Requiring Urgent Revision In AS/NZS 3000: 2018

Section 5 Earthing Arrangements and Earthing Conductors

5.1 General

5.1.1 Application

This section specifies the minimum requirements of Standards for the selection and installation of earthing arrangements.

Comment: The minimum requirements are not satisfied as per **AS/NZS 3000: 2018 Part 1** as it fails to provide protection against electric shock and fire.

5.1.2 Selection and Installation

Earthing arrangements shall be selected and installed to perform the following functions or have the following features:

***Clause A:** Enables automatic disconnection of supply in the event of a short circuit to earth fault or excessive earth leakage current in the protected part of the installation through the protective earthing arrangements*.

Comment: Recent PV Solar, EV charging stations and Battery fires are clear examples of a failure of the existing protective equipment and strategies, which are proving inappropriate.

***Clause C**: Voltage difference should not appear between the conductive parts of equipment and extraneous conductive parts;*

Comment: represents a failure in the minimum requirements for the selection and installation of earthing arrangements when applied to renewables (Type A RCD's DC Voltage Leakage components)**.**

***Clause D:** Provide an effective and reliable low impedance fault path capable of carrying earth fault and earth leakage currents without danger or failure from thermal electro-mechanical, mechanical and environmental and other external influences.*

Comment: A breakdown in earthing integrity such as this can result in an extremely dangerous situation on an MEN system (PE) caused by the following fault conditions:

- Loss of supply neutral
- Loss of supply earth
- Short circuit
- Corroded or damaged earth electrodes
- Loss of MEN bond
- Reverse polarity
- Island Mode (earth)
- Voltage Rise/Cumulative Impact.

An **RCD will not provide** electrical protection against any of the above-mentioned Fault Conditions because they are upstream of the Toroidal Coil and the RCD cannot distinguish between neutral current and fault current.

Amendments to Figure 5.1 MEN

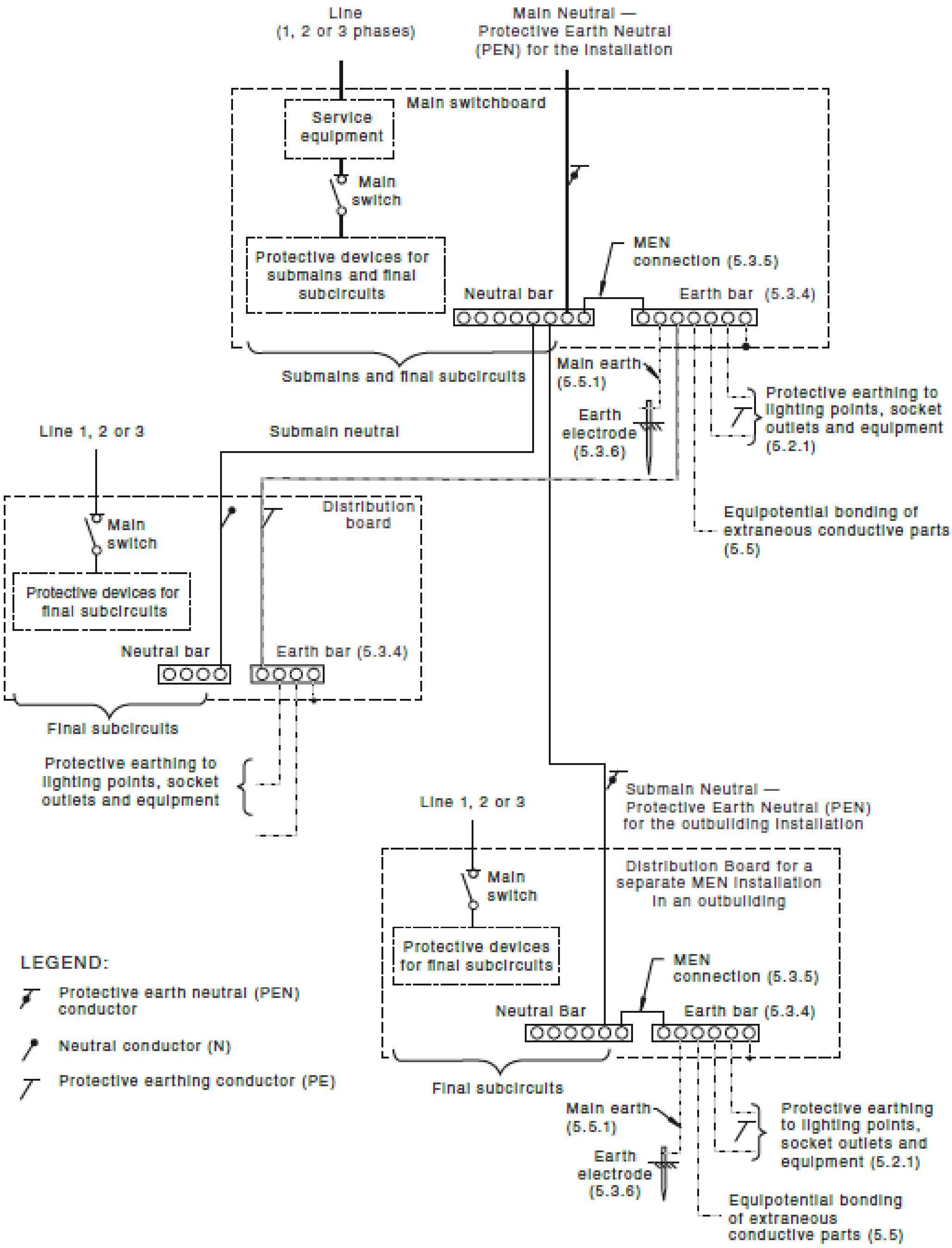
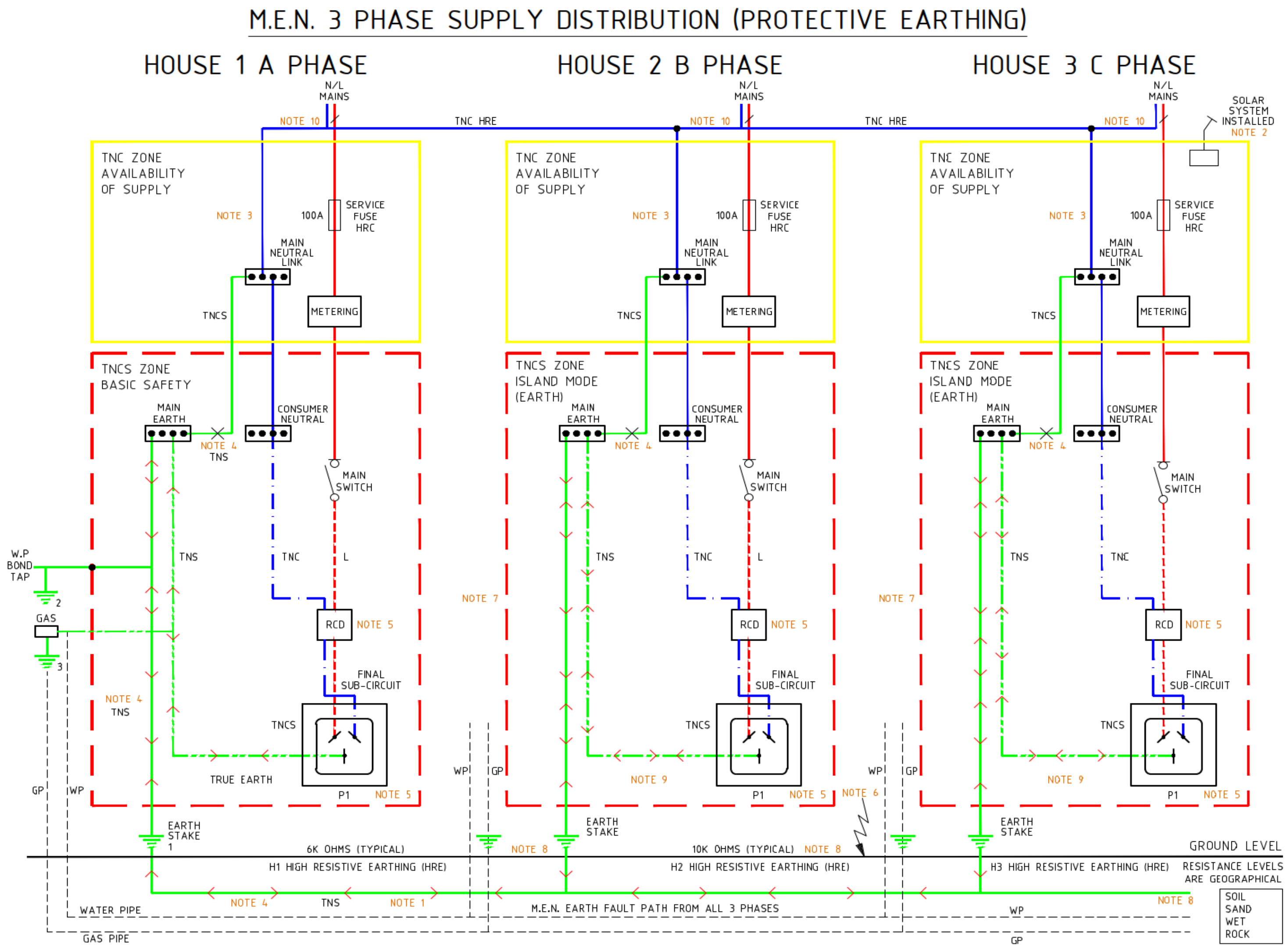


Figure 5.1 (above) fails to provide details on the true earthing landscape and is clearly outdated due to the many changes which have resulted or been implemented since the **TN-C-S-MEN** inception. The multiple use of the **TN-C (PEN/HRE)** and the **TN-C-S MEN (low impedance earthing)** earthing systems is not defined, and fault types not detailed. Figure 5.1 provides little clarity and provides no correlation to an installation **(resulting in the mandated Type change of RCD)** making it difficult for an Electrician, Engineers and Designers to understand this complex and very important area of **TN-C-S MEN 3 Phase Earthing**. Refer to **Drawing A** which provides clarity on the issues detailed below.

Drawing A

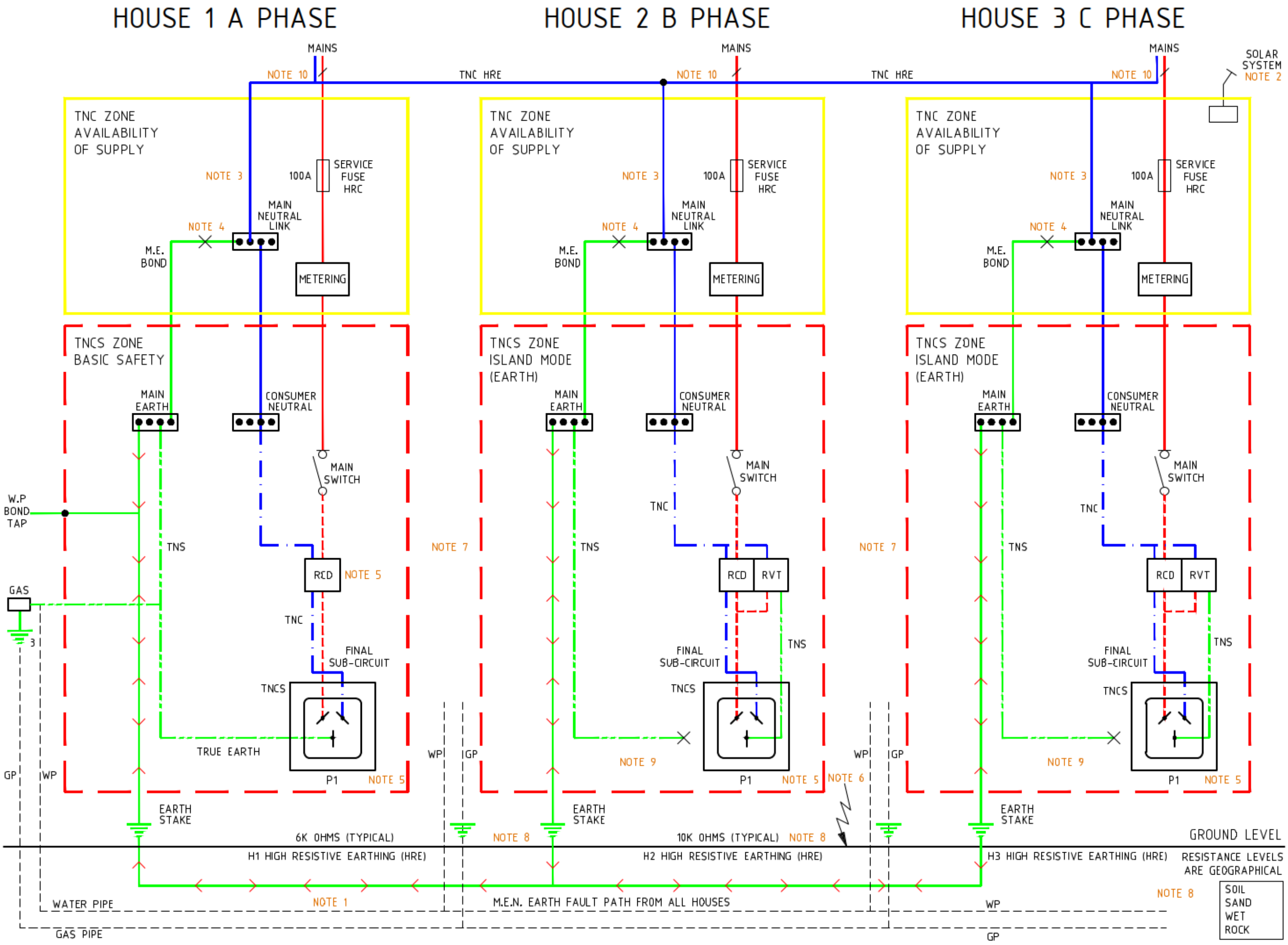


TN-C-S MEN – 10 DANGEROUS FAULT CONDITIONS (NOTES)

1. A FAULT CAN APPEAR ON ALL 3 HOUSES. TN-C-S MEN SYSTEM
2. A FAULT ON H3 SOLAR CAN SUPPLY A DANGEROUS VOLTAGE RISE ON H1 AND H2. (SEE A2) SOLAR 2nd MEN POINT
3. LOSS OF SUPPLY NEUTRAL ON H1 CAN CAUSE A VOLAGE RISE ON H2 AND H3
4. LOSS OF M.E ON H1 CAN CAUSE A VOLTAGE RISE ON H2 AND H3
5. MAIN EARTH AND MAIN NEUTRAL FAULTS ARE UPSTREAM OF RCD'S. RCD'S PROVIDE NO PROTECTION
6. LIGHTNING STRIKE. TN-C-S EARTHING
7. WATER PIPE BOND NOT REQUIRED ON PVC PIPING- ISLAND MODE.
8. SOIL RESISTIVITY. HIGH RESISTIVE H1 TO H2 6K OHMS (TYPICAL) H1 TO H3 10K OHMS (TYPICAL)
9. ISLAND MODE- NO TRUE EARTH. MEN IS COMPROMISED (PROBABLE TT EARTHING SYSTEM)
10. REVERSE POLARITY: IS VERY DANGEROUS AND USUALLY OCCURS AT THE SUPPLY POINT BY THE SERVICE WORK OF UTILITY PROVIDER. THE NEUTRAL AND EARTH ARE NOW ACTIVE THUS ALL METAL PARTS BECOME LIVE AND THE RCD WILL NOT PROVIDE PROTECTION

Drawing A01

M.E.N. 3 PHASE SUPPLY DISTRIBUTION (PROTECTIVE EARTHING) & RVT-HRE



TN-C-S MEN – 10 DANGEROUS FAULT CONDITIONS

AS LISTED IN DRAWING A, IN HOUSE 1 BUT ELIMINATED IN THE RVT PROTECTED HOUSE 2 & 3.

Localising the Fault

Localising the fault is the isolating of a fault to a specific circuit, eliminating cascading and the 10 dangerous faults (listed at the bottom of Drawing A) of the MEN Earthing System. These fault conditions are all upstream of the RCD, and are eliminated, when combining the RCD/RVT Technology with the HRE method and removal of the PE. The detection of voltage brings rapid isolation of electrical faults, enabling superior electrical safety outcomes for domestic & commercial final sub-circuit applications.

In addition, this is a **significant benefit for Electricians and Utilities** in fault finding, due to the removal of cascading fault issues, saving time, money and equipment damage. Renewables applications (eg; Inverters and Converters) will also benefit significantly in terms of fault finding.

Conclusion

The **TN-C-S MEN Low Impedance Earthing System for Final Sub-Circuits is Compromised**, placing Individuals' Safety at Risk from Electric Shock and Fire. The impact of NCC (National Construction Codes) and BCA (Building Code of Australia) changes, Outdated Standards, the uptake of Renewables and Energy Micro Grids together with the Incompatibility of Earthing Systems (TN-C and TN-C-S MEN) **has caused a Breakdown of the Basic Safety Principles of the TN-C-S MEN System**.

The Combination of Current and Voltage fault detection, proposed as part of this solution, enables a broader range of fault detection through additional Layers of electrical protection and elimination of the documented dangerous fault conditions. **The RVT-VMD Technology when applied in HRE earthing** provides new benchmark levels of safety with the TN-C-S MEN Earthing System safety outcomes not compromised.

Standard Test Equipment available for testing operations of RCD's, can be used to test the RCD/RVT to validate an effective earthing system through mandatory testing **AS/NZS 3000:2018 Section 8 Verification**.

The RCD/RVT solution does not require retraining of electricians and designers of electrical installations, due to the detail of drawing A01.

Recommendations

Recommendation 1: Deletion of **AS/NZS 3000 Section 5.1.4 Example 3** *(See **Photo 5 & 5a**).*

AS/NZS 3000:2018-Alternative Earthing Arrangements

Clause 5.1.4 Other Earthing Systems - *"Alternatives to the MEN system may be permitted, provided that the requirements of Part 1 of this Standard are satisfied, taking into account any effects on the distribution system supplying the installation… **Example 3** Existing installations may still remain connected under former direct earthing or voltage operated earth leakage circuit breaker (ELCB) systems permitted by superseded editions of this Standard".*

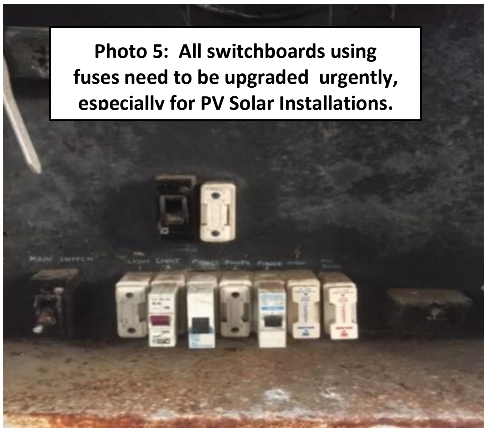


Photo 5: All switchboards using fuses need to be upgraded urgently, especially for PV Solar Installations.

Photo 5a: Switchboard Updated using RVT-VMD.

Justification: 'Electrification to Renewables'
resultant problems outlined and **NCC** mandated replacement of copper and galvanised piping, which have given rise to **'Island mode'.** The random rollout of single-phase PV Solar Arrays onto the 3 Phase Distribution System does not suit direct earthing or ELCB protective systems and are inappropriate for modern electronic technologies. Renewables as Alternative Power Supplies (IT supply), fall under **AS/NZS 3000:2018 Section 7.4**, which when earthed and linked to the TN-C-S MEN earthing system, results in a double MEN point, dangerously unsuited for an installation which includes copper piping.

An electrical upgrade is required for installing of PV Solar Systems but does not fall under the scope of **AS/NZS 5033:2021**, a separate jurisdiction and **hence cannot be enforced**. This is important as the majority of houses in Australia still have switchboards and copper piping as pictured. The removal of the equi-potential bonding by the insertion of non-metallic piping **reduces the risk of voltage rise** on extraneous metal water pipes and taps. This simple and low-cost solution is easily attainable *(See Photo 5a)*.

Earthing Model with HRE at Final Sub-circuit remains TN-C-S MEN and meets the requirements of AS/NZS 3000:2018 Part 1. Extraneous metal parts, when present in a HRE Installation, are no longer a risk due to Island Mode and Class II Appliances. Equi-potential bonding and rapid isolation in a final HRE Sub-circuit are still present.

Sadly, the **Denishar Woods case *(Denishar Woods Vs WA Govt & others)*** underlines the significance of the Loss of the PEN, had the inclusion of a non-conductive insert been in place in the copper water pipe front tap, **this tragic incident would have been prevented.**

"Where it is possible to safe-guard against a foreseeable risk, which…… by adopting a means, which involves little difficulty or expense, the failure to adopt such means will in general be negligent." (**Chief Justice Sir Harry Gibbs of the High Court of Australia**).

Recommendation 2: Statement for inclusion- *"All external Water Tap pipes must be of a non-conductive type or have a non-conductive insert installed above ground and within 1 metre of the First external Water Tap handle."*

Justification: A fault on the protective earth (PE) which includes a non-conductive insert, isolates individuals from exposure to electric shock, electrocution and effects of EMR from all copper piping and external taps.

Recommendation 3: Deletion of the link marked as **X** (Figure F2) on the line side of the 12v D.C. ELV to the 230v A.C. LV output.

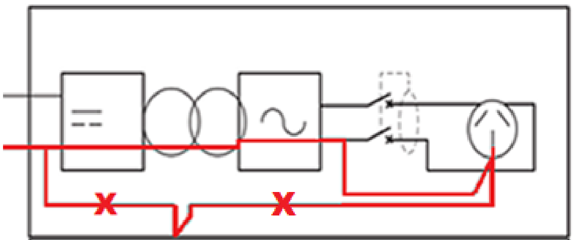


Figure F2 RCDP Inverter (P 45)
From AS/NZS 3012: 2019 – *Electrical Installations Construction & Demolition Sites.*

***Note 1: AS/NZ3000:2018 Appendix Q9**, states "An inverter providing 230 volts AC supply output should be insulated from the 12 Volt DC battery input as under some fault conditions the DC supply can rise to the potential of the AC output of 230 volts". Figure F2 clearly shows a potential fault path in red between the 12V and 240V sides of an inverter, highlighting **a segregation issue** and conflicting with the requirements of **AS/NZS 3012:2019** (Electrical Installations Construction & Demolition Sites) and thus enable a dangerous condition to exist.*

Justification: Segregation is a critical issue and can only be achieved by removal of the return path to the ELV input. This reduces the risk of circulating currents which can rise to levels below the RCD threshold of 30mA and cause damage to the ELV 12V D.C. side of an installation causing catastrophic damage to equipment including batteries, BMS and inverters resulting in fire and electrical shock. The Verification Panel and field testing proved that voltage rise occurs on the output earth as per **Appendix Q9 Note 1** above.

Recommendation 4: Inclusion of Drawing A as Figure 5.1 (a) in **Standard AS/NZS 3000:2018 Clause 5.1.4;**
On Drawing A Note 5: The maintenance of the TN-C-S system is critical to the correct functioning of protection systems whereas the HRE enables high level protection with a breakdown of the Protective Earth.

Photo 6: Earth Stake - Electrolysis Corrosion (DC).

Justification: Failure of the low impedance earth environment is very common, often unrecognised, and potentially extremely dangerous in all areas of electrical distribution including residential, commercial, and industrial. With such a failure, the result is a high impedance or HRE outcome whereby the RCD becomes impotent. Utilisation of HRE at Final Sub-circuit reduces the risk. **Photo 6** shows a 5 year old earth electrode (installed in high acidic soil) clearly shows what can happen as earth bonds and earth electrodes are rarely verified.

Drawing A provides a more accurate representation of the MEN Earthing system than Figure 5.1. The Drawing A Notes depict the fault types that have existed and those introduced with the **Transition to Renewables** and the resultant changes caused by the removal of multiple earthing points through the **introduction of Polybutylene tubing, PVC pipes and mandatory Wet Area Waterproofing** requirements which have resulted in the Island Mode phenomenon.

Recommendation 5: Inclusion of HRE Earthing Model as per Drawing A01 as Figure 5.1.4a.

Justification: The HRE at final sub-circuit earthing method satisfies **AS/NZS 3000:2018 Clause 5.1.4. Example 5** Electrical installations complying with IEC 60364 series, permits the use of **TN, TT and IT** earthing systems as alternatives to the MEN system. **HRE is part of the TN Earthing system as a combination of the TN-C and TN-S Earthing systems** as shown in Drawing A01 and thus **satisfies the requirements of Part 1 of this Standard** *taking into account any effects on the distribution system.*

Utilising a High Resistive Earth (HRE) at final sub-circuit, without a Protective earth (PE), **significantly reduces the risk of a person coming into direct contact** with a fault condition on the Main Earth. The RCD/RVT, when combined with the HRE, provides electrical protection against the fault conditions outlined thus enabling improved safety outcomes as detailed in the attached Risk Matrix. The combined RCD/RVT and HRE Solution reduces the risk of fire and electric shock by utilising the benefits of both RCD Current detection and Voltage detection, which isolates at a pre-determined level of 43V, **below 'Touch Potential' let-go threshold**, lowering the fault level to **10mA** on outlets and appliances**,** *(as stated on **Page 17** of this report).*

<u>Annexures</u>

RVT-VMD Design & Test Specifications.

1.	Dual Operational Voltage:	**110-230 volts AC-DC**
2.	Voltage Sensing:	43 volts (+/- 5%)
3.	Voltage Monitoring Tripping Current:	10 mA
4.	Test Tripping Current:	30 mA
5.	RCD Tripping Current	30 mA
6.	Frequency:	50/60 Hz
7.	Insulation Protective Level:	Class ll (Double Insulation).
8.	Correct Polarity:	A & N + FE
9.	Capacitive Leakage Current:	< 1 mA
10.	Triggering AC Waveform:	Both half cycles

The operational features of this solution enhances electrical safety to the next level, by **utilising both Current and Voltage fault detection**, enabling operation in both **AC and DC Voltages at 110V to 230V** with detection at **10-30mA** fault current level**.**

Verification Panel

The image below shows a panel designed to verify the results of the assertions made in this document by replicating a typical 3 phase installation in a domestic setting. Some of the failings of the **TN-C-S MEN** earthing system were unexpected with outcomes not confirmed until the various fault scenarios were conducted in the 3-phase configuration.

Testing carried out using the **Verification Panel culminated in the development of the Risk Matrix**, where **10 separate faults conditions** were identified being rated from **Extreme to a High Safety Risk of Electrocution, Electric Shock or Fire**. It should be noted, the **High Resistive Earthing** combined with the **RCD/RVT** significantly reduces the risk of all these fault conditions at the **Final Sub-circuit to a Low Risk**.

Risk Matrix Comparison for TN-C-S MEN (Low Impedance) and TN-C-S MEN (HRE) + RVT

Final Sub-circuit Risk Matrix Comparison					
Fault Type	Earthing Zone	Earthing Arrangement	Associated Risks	Risk Level RCD+ Low Impedance	Risk Level RCD+ RVT+ HRE
Reverse Polarity	TN-C	TN-C Consumer Mains	Electrocution and Fire	Extreme	Low
Loss of Supply Neutral	TN-C	TN-C Consumer Mains	Electrocution and Fire	Extreme	Low
Loss of Main/Supply Earth	TN-C	TN-C Consumer Mains	Electrocution and Fire	Extreme	Low
Short-circuit/ Arc Flash	TN-C-S	TN-C-S MEN Main Sw./Bd.	Electrocution and Fire	Extreme	Low
Low level Current Leakage to earth	TN-C-S	TN-C-S MEN Main Sw./Bd. or Final sub-circuit	Fire	Extreme	Low
Corroded/ damaged Earth Electrode	TN-C-S	TN-C-S MEN Main Sw./Bd.	Electric Shock and Fire	High	Low
Loss of MEN Bond	TN-C-S	TN-C-S MEN/TNC Main Sw./Bd.	Electric Shock and Fire	High	Low
Voltage Rise	TN-C-S	TN-C-S MEN/TNC Main Sw./Bd.	Electric Shock and Fire	High	Low
Island Mode	TN-C-S	TN-C-S MEN Main Sw./Bd.	Electric Shock and Fire	Medium	Low
Electric Surge	TN-C-S MEN	TN-C-S MEN Main Sw./Bd.	Damage to Equipment-RCD may not function	Medium	Low

WWEST RISK MATRIX	Consequence			
Likelihood	Major (Death / Disability)	Serious (Serious / Hospitalization)	Minor (First Aid)	Insignificant (No Injury)
Almost Certain	Extreme	High	High	Medium
Likely	High	High	Medium	Medium
Unlikely	High	Medium	Medium	Low
Remote	Medium	Medium	Low	Low

Due Diligence

Unless the risk issue under consideration is truly novel, most of the precautionary options available to address any problem have already been tried by others. In the first instance at least, the precautionary, due diligence approach suggests that by firstly considering these options enables a solution-based, generative, can-do outcome amongst stakeholders. It also provides an arguable case before the courts, post-event.

Earthing Scenario Protection Comparison Chart

Earthing Scenario Protection Comparison Chart					
	Earthing Scenario	**Detection Method**	**Protective Device**	**Outcome**	**Comment**
Existing	TN-C-S MEN	Current Leakage	RCD	Low Impedance Earthing TN-C-S MEN + PE) + RCD = ***Class 1 Protection***	Effective while conditions good, but easily Compromised with Loss of Neutral or Earth etc.
Existing + Renewables	TN-C-S MEN	Current Leakage	RCD	Low Impedance Earthing (TN-C-S MEN + PE) + RCD = ***No Protection***	RCD's do not provide electrical protection in High Impedance or Unearthed applications
Future + Renewables	TN-C-S MEN + HRE	Current Leakage **+** Voltage Leakage	RCD **+** RVT	High Resistive Earthing at Final Sub-circuit (TN-C-S MEN + HRE) + RCD/RVT = ***Class 11 protection***	Ultimate level of protection providing enhanced levels of Safety in all Earthing Systems and Scenarios

Geoff Cronshaw (Chief Electrical Engineer at IET)

Amendment 1 to BS 7671:2018+A1 on EV Charging Stations/Outlets

Amendment 1 of BS 7671:2018 was published at the beginning of February this year and may be implemented immediately. The amendment concerns Section 722 of BS 7671:2018 (electric vehicle charging installations). In this article, we give a brief overview of some of the main changes to Section 722.

Protection against electric shock
Regulation 722.411.4.1 concerning the use of protective multiple earthing (PME) supply has been redrafted. Indent (iii) has been fully revised. In addition, Regulation 722.411.4.1 now includes an additional indent (iv) to cover single-phase installations and a further additional indent (v) has been added. Regulation 722.411.4.1 does not allow PME to be used to supply an electric vehicle (EV) charging point located outdoors (or that might be used to charge a vehicle located outdoors) unless you meet (i) or (ii) or (iii) or (iv) or (v) of 722.411.4.1.

A summary of the requirements of the indents to **Regulation 722.411.4.1** is as follows;

- *Regulation 722.411.4.1(i) refers to a situation where a connecting point is supplied from a three-phase installation used to supply loads other than charging points and where the load is sufficiently well balanced.*
- *Regulation 722.411.4.1(ii) requires a very low resistance earth electrode to mitigate the effects of an open-circuit (PEN) conductor fault on the supply.*

References:

[1] **Dinesh Kumar, Firuz Zare, and Arindam Ghosh** "DC Microgrid Technology: System Architectures, AC Grid Interfaces, Grounding Schemes, Power Quality, Communication Networks, Applications, and Standardisation Aspects"

[2] **Taylor Callen – Thesis Paper** - "Earthing Systems in Relationship to the Characteristics of Protection Devices" (University of Newcastle).

[3] **E. Stanton Maxey M.D.** "A Lethal Subtle Energy"

[4] **Trevor Blackburn, Associate Professor University of NSW**, **School of Electrical Engineering & Telecoms** "RVD White Paper, Alternative Earthing Method"

[5] **Cahier Technique** Merlin Gerin. Cahier Technique 173 Earthing Systems Worldwide and Evolutions. Technical Report 1, September 1995

[6] **Paul Malanchuk (Director) Electrical Projects Australia**
*Independent Review of WWEST RVT Technology for **PSOA** (June 2022)*

[7] **Paul Malanchuk (Director) Electrical Projects Australia**
*Independent Review of WWEST RVT Technology for **Final Sub Circuits** (2022)*

[8] **Sam Dib – BE MIE Aust C.Eng. NER RPEQ (3495475)**
Unique PSOA Report – Independent Review

[9] **Australian Government - Department of Industry & Science**
https://www.energy.gov.au/households/solar-pv-and-batteries#:~:text=Australia%20has%20the%20highest%20uptake,have%20been%20installed%20across%20AAustralia

[10] **Fluke corporation. Earth Ground Resistance 2006**

[11] **ABB Pocket Book – Switch Gear Manual (10th Revised Edition)**

[12] **Geoff Cronshaw (Chief Electrical Engineer at IET) BS 7671 Amendment 1 (2018)**

[13] **Master Electricians Australia – Federal Budget Submission (2019)**

Validation for Removal of AS/NZS 3000:2018 Clause 5.1.4. Example 3.

The removal **AS/NZS 3000:2018 Clause 5.1.4. Example 3** is of critical importance to consumer electrical safety due to the following Distribution and Installation Earthing issues:

Distribution:

- TNC Earthing is regarded as the most dangerous Earthing Method from a safety perspective due to EMC Leakage emanating from Electronic Inverters and DC Voltages (PV Solar),
- The TNC Earthing Method is not suitable for Renewables- PV Solar, Battery storage systems and Grid EV Charging Stations, due to dangerous and uncontrollable Voltage Rise on the Protective Earth.

Installation:

- Independent Research by **Master Electricians Australia in their Federal Budget Submission (2019),** highlighted;
  *"**40 per cent** of Australian homes remain completely unprotected by safety switches. The same report also estimated that approximately **30 per cent** of homes have coverage of their power outlet circuits only, and a further **30 per cent** have the light circuits covered as well".*
- However, despite these facts *"only **60 per cent** of homes have safety switches fitted".*
- The use of Fuses and ELCB with Renewables, are not suitable and require urgent upgrading (see photo 5) as currently Type A RCD's are now mandatory in all other installations,

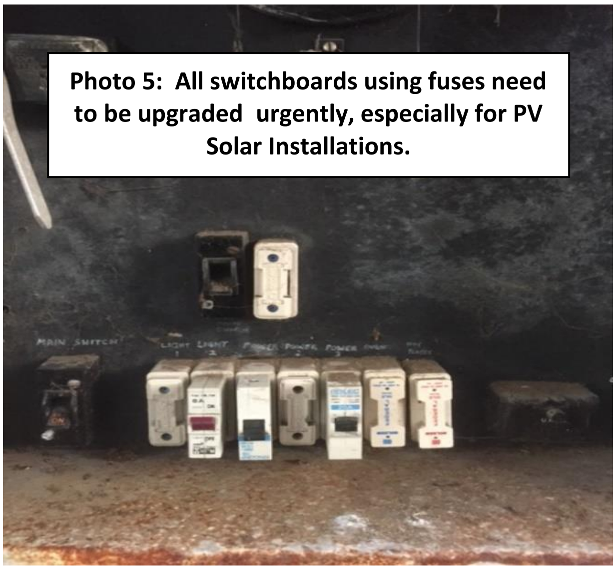


Photo 5: All switchboards using fuses need to be upgraded urgently, especially for PV Solar Installations.

- Existing installations under the former direct earthing method (40+ years old) are still permitted by superseded editions of this Standard. These installations represent a critical safety risk to consumers especially when installed with or located near an adjoining PV Solar Installation,
- Copper Piping (present in approx. 70% of housing) is not suitable for Renewables due to the creation of a 2nd MEN Point- expressly prohibited by Standards,
- Separate metal piping entering a property (water and gas) will result in a 2nd and 3rd MEN Point.
- As shown in Photo 5, all fuse mounted Switchboard Panels were manufactured using asbestos. This issue alone represents an Extreme Safety Risk for electricians and potential Solar PV Installers.

Worst Case Scenario for the Transition to Renewables

The impact of Voltage Rise caused by Renewables onto the earth and subsequent Multiple Earth Points (Water and Gas piping) in older Sub-Divisions or Class 2 Housing Installations, could see those areas at serious risk if a fault condition were to occur.

- The Cumulative Impact of EMC Leakages will also result in significant Voltage Rise on Earth Points (photo 4),
- The 10 known fault condition, outlined previously, will be exacerbated, increasing Consumer Safety Risk,
- The mandatory change from 'Type AC' to 'Type A' RCD's for safety reasons, when it is well recognised that Type A RCD's do not provide protection against Smooth DC Leakages which emanate from PV Solar, Battery Storage and EV Recharging scenarios,


Photo 4: EMC Degradation of galvanised steel in a switchboard.

- The UK is now recommending a move away from 'Type A' RCD's to 'Type B' RCD's for PV Solar, Battery Storage and EV Recharging scenarios due to the DC problem,
- British Standard BS7671 has banned the use of TN-C-S Earthing for External EV Charging Stations and have nominated the use of alternative Earthing Methods such as TN-S or TT with separate Earth Stakes a minimum of 10M from the existing PEN Earth Stake and extraneous Metal Piping (Copper Water & Gas Piping).

Cost Implications

- The safety implications of the Transition to Renewables and impact on the MEN Earthing System will urgently require all dwelling to have RCD's installed, critical for Consumer Safety,
- The significant cost implications of the mandated change from a 'Type AC' to 'Type A' RCD of the estimated 9.7 Million Electrical Circuits ($3.9 Billion) **for a Solution which does not resolve the risk**.
- Based on the ABS Census data (August 2016), Master Electricians Australia have estimated that there is a deficit of around **30 million safety switches** in homes across Australia. This is calculated by considering the number of houses built under each era of wiring rules, and how many safety switches each is likely to have, and assuming (conservatively) that each home should have four safety switches to cover all its circuits
- **Figure 7.1** below is a table from the **Master Electricians Australia** (2019 Federal Budget Submission), where they estimated a deficit of safety switches in the national housing stock of somewhere between **19.4 and 32.3 million,** based on the age of Australia's housing stock.

Figure 7.1 Estimated safety switch shortfall based on age of housing stock

Housing era	Number of houses	Safety switches needed per home for full protection	Total safety switches needed
Pre 1991 homes (Safety switches not included in construction)	5,852,500[viii]	Four extra switches per home	23,410,000
1992-2001 homes (Safety switches on power circuits included in construction)	1,219,700[ix]	Three extra switches per home	3,659,100
2001-2016 homes (Safety switches on power and light circuits included in construction)	2,619,882[x]	Two extra switches per home	5,239,764
All homes (2016)	9,692,082	N/A	**32,308,864**

- The **Master Electricians Australia Submission** (2019) also stated that *"some older homes will have received safety switches through renovations or money-making activities such as sale or rental. However, even if all existing homes had safety switches on power & light circuits, the national housing stock of 9.7 million would require an additional 19.4 million safety switches to achieve a full level of protection. This indicates a deficit of safety switches in the national housing stock of somewhere between **19.4 and 32.3 million**.*

Independent Review – Summary

Electrical Projects Australia (EPA) – Dec 2022.

Independent Engineering testing by Electrical Projects Australia found the following in relation to what changes etc. can be expected in the deployment of the RVT technology:

a. The RVT technology is proposed to be used in conjunction with existing RCD technology, so all the protection that is provided by RCD's does not change, but it is complemented by the additional protection provided by the RVT device as noted above.

b. Standard test equipment that is currently available to test operation of RCD's can be used to test the RCD/RVT combination proposed for final subcircuits, along with the inbuilt test button. So, there is no requirement for re-training or the like with the introduction of this new protective device.

ELECTRICAL PROJECTS AUSTRALIA Pty Limited

INDEPENDENT REVIEW OF
WWEST – RVT TECHNOLOGY FOR FINAL SUB-CIRCUITS

Prepared by:
Electrical Projects Australia
368 Maitland Road
PO Box 365
MAYFIELD NSW 2304
Phone: 02 4967 5999
Facsimile: 02 4967 5933
Email: mail@electricalprojectsaustralia.com.au
ABN 72 053 112 502

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1.1 GENERAL

We have been requested by WWEST Pty Ltd to carry out an independent review of their RVT technology proposed to be utilised for final sub-circuit protection.

1.2 ASSESMENT

Our desktop review of the technology and review of live demonstrations of various scenarios, including loss of earth and loss of neutral, which are common 'real-world' situations, it was evident to me that the RVT technology has some tangible benefits over the common protection technology for final sub-circuits which is typically just a 30mA RCD.

This is particularly relevant when we examine final sub-circuits to equipment and devices as the majority of those items are now electronic which general involves the inclusion of DC power supplies.

If we look at a typical domestic situation, then the lighting is generally LED technology, which requires DC power supplies.

This also applies to many new appliances also as over the years we have seen a move towards class II equipment due to the heavy use of electronics, which is primarily DC technology, and much less ferro-magnetic technology, so having a technology suited to these types of devices is a benefit.

One device that is having a major impact on the electricity network, including final sub-circuits is PV Solar systems. These are being installed to domestic installations in Australia at one of the highest rates in the world, however there are some major issues around these PV Solar Systems, which are yet to be addressed in terms of suitable protection as the existing protection equipment and strategies are proving not to be appropriate.

The same can be said for the more recent addition of EV Chargers to our final sub circuits. In a similar fashion to PV solar systems, because they are large electronic or DC loads, it is being found that the existing protection equipment and strategies are proving not to be appropriate. This is evident when you consider the recent changes to our local RCD standards as well as changes to international standards.

We believe that the benefits of the proposed RVT Technology by WWEST Pty Ltd include the following:

a. Protection against loss of neutral.

b. Protection against loss of main earth and M.E.N. bond.

c. Combined current and voltage fault detection.

d. Lower fault level detection (10mA – 30mA).

e. High impedance earth connection within the RVT device reduces fault level outlets/appliances.

We have also found the following in relation to what changes etc can be expected in the deployment of this proposed RVT technology.

a. The RVT technology is proposed to be used in conjunction with existing RCD technology, so all the protection that is provided by RCD's does not change, but it is complimented by the additional protection provide by the RVT device as noted above.

b. Standard test equipment that is current available to test operation of RCD's can be used to test the RCD/RVT combination proposed for final subcircuits, along with the inbuilt test button. So, there is no requirement for re-training or the like with the introduction of this new protective device.

1.3 STATEMENT

I, Paul Malanchuk, the director of Electrical Projects Australia, and practicing Electrical Engineer for over 25 years declare that I am in support of the proposed RVT technology by WWEST Pty Ltd to be used as part of final sub-circuit protection as I believe that it can provide additional safety benefits over an RCD only protected final sub-circuit.

This is based on my review and research into the proposed RVT technology which I declare was carried out with due diligence and to the best of my ability.