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GUIDELINE ON EARTHING AND BONDING AT RAILWAY STATIONS

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Table of contents

1. Purpose 3
2. Scope 3
3. Introduction 4
4. Effects of DC Stray Current 5
5. Earthing and Bonding Issues 6
5.1 Bonding 6
5.2 Earthing 10
5.3 Separation issues 12
5.4 Isolation issues 20
6. Conclusion 26
APPENDIX 1 28

1. Purpose

The purpose of this document is to promote an awareness of earthing and bonding issues prevalent at railway stations. This document has been produced for internal RailCorp use only. It is particularly targeted for non-electrical persons such as project managers, asset engineers, external party works, etc carrying out either construction or maintenance work at railway stations.

This document is not intended to be included in any technical brief for tendering purposes and is not a substitute for appropriate engineering design guidelines.

2. Scope

The overall scope for this guideline targets railway stations within the RailCorp 1500 volt direct current electrified traction system.

Specifically, the contents of this document relate to the interface of the traction 1500V DC traction system, high voltage reticulation system and low voltage distribution systems. Electrical hazardous situations may exist at railway stations due to these interfaces, resulting in issues relating to earthing and bonding.

The implications for not addressing risk management strategies relating to earthing and bonding issues has ramifications on safety and infrastructure integrity, including economic and operational impact.

The outcomes of this guideline are as follows:

- promote an awareness of earthing and bonding issues prevalent at railway stations and to educate persons responsible for either construction or maintenance work at railway stations.
- reduce to a level as low as reasonably practicable the risk of injury from electric shock from accessible and touch voltages.
- reduce to a level as low as reasonably practicable the export of stray current from DC traction systems.

3. Introduction

RailCorp needs to safeguard itself against risk of damage, fire, electric shock or loss of life due to risks from faults etc., associated with its 1500V DC traction system, high voltage reticulation system and low voltage distribution systems.

At railway stations, three main types of risks may exist:

1. Risks associated with 1500V DC stray leakage or fault current.
2. Electric shock risk due to 1500V DC touch & step potential rise under fault condition, in particular with regard to remote earths in accordance with EP 00000008SP.
3. Electric shock risk due to high voltage/low voltage distribution systems' touch & step potential rise under fault condition, in particular with regard to different earthing systems.

With the proliferation of railway station upgrading work and associated construction of station canopies, the incidence of electrical hazardous situations has increased. The majority of these situations relate to issues of earthing and bonding.

There is a possibility that overhead wiring structures may rise to a potential above earth. The risk of persons receiving an electric shock when standing beside an overhead wiring structure and touching the structure is present and is of concern. Other hazardous situations where persons could receive an electric shock is when physical contact is made by touching overhead wiring structures at the same time as they touch lighting poles, metallic parts of canopies or awnings, steel troughing, metal fences or rolling stock.

In order to minimise these risks, methods have been developed and deployed for the overhead wiring system which are detailed in RIC standards. Selected extracts from relevant RIC documents dealing with railway station earthing and bonding requirements are in Appendix 1.

One of the more common control measures used at stations is to separate overhead wiring structures by distance from any other components on the station. However, station upgrading work has often compromised this control, along with other earthing and bonding issues.

4. Effects of DC Stray Current

DC traction systems may cause stray currents which could adversely affect both the railway and / or outside interests. The major effects of stray currents can be:

- corrosion and subsequent damage of metallic structures where DC stray currents leave the metallic structures;
- the risk of overheating, arcing and fire and subsequent danger to equipment and people, both inside and outside the rail corridor;
- influence on services and communications systems;
- influence on unrelated cathodic protection installations; and
- influence on unrelated AC and DC power supply systems and their associated earthing systems.

There are three principal measures available to minimise stray current emission from a DC traction electrification system:

1. insulation of the traction return circuit with respect to earth;
2. improvement of the conductivity of the return circuits; and
3. design of the traction power supply system.

In the past, earthing and bonding issues have been “designed out” of the rail system, where possible. However, with the advent of major station upgrading programs, considerable problems now exist at many stations where station upgrading work has installed canopy awnings on platforms and station concourses. Typically, many of these projects were “design and build” tenders, with the designer not always taking into account the issues associated with earthing and bonding.

The problem of minimising stray current is closely related to the problem of earthing and/or bonding of metallic structures to prevent electric shock to people. The solutions to both problems often come down to a compromise since the 'best' solution for one situation may result in major problems for the other issues. However, protective provisions against electric shock take precedence over provisions against the effects of stray current.

5. Earthing and Bonding Issues

Earthing and Bonding Issues may be categorised into the following sub-headings:

- 1500 Volt Bonding
- Earthing
- Separation issues
- Isolation issues

More often than not, earthing and/or bonding issues are inter-related and may involve one or more, or a combination of the sub-headings.

Many earthing and bonding strategies are conditional upon the particular configuration of the station and the earthing and bonding philosophy adopted for each unique situation. In some instances, especially at larger complex stations, the separation issues may become too complex and too difficult to adequately control and monitor.

In these situations, one option is to interconnect all metallic structures etc. to overcome possible touch potential problems, thus negating the separation issues. However, there are also negative trade-offs with this option.

As previously stated, the resultant solution to many earthing and bonding issues often come down to a compromise solution. This especially applies to configurations where these issues have not been adequately addressed in the design stages.

The following headings give a background on the outstanding issues relating to each category. Descriptions, and in some cases photos, are given in each case to clarify “poor” design configurations as opposed to “good” design configurations.

5.1 Bonding

Examples of bonding issues are, but are not limited to:

- bonding of steel/metal footbridges (OHW attached)
- bonding of overline traffic bridges (OHW attached)
- bonding of 1500 V structures in vicinity of station as per standards
- bonding of safety screens as per standards

A number of possible bonding arrangements exist for railway stations, depending on the configuration and physical arrangement of overhead wiring supports, the station premises and canopy design.

The bonding arrangements for stations, station bridges and overline traffic bridges are covered in documents EP 12 20 00 01 SP “Bonding of Overhead Wiring Structures to Rail” and EP 08 00 00 07 SP “Safety Screens for Bridges over 1500 V OHW Equipment”

There is a possibility that overhead wiring structures may rise to a potential above earth. The risk of persons receiving an electric shock when standing beside an overhead wiring structure and touching the structure is present and is of concern. Other hazardous situations where persons could receive an electric shock is when physical contact is made by touching overhead wiring structures at the same time as they touch lighting poles, metallic parts of canopies or awnings, steel troughing, metal fences or rolling stock.

In order to minimise this risk, methods have been developed and deployed for the overhead wiring system.

A number of selected OHW structures in the traction system are required to be bonded to rail. The determination of the policy on which structures are to be bonded has involved a risk assessment to identify the most likely locations and situations giving greatest exposure to risk. As can be seen from the dot points below, station platforms pose the greatest threat of this risk exposure.

Overhead wiring (OHW) structures, and other structures that support 1500V overhead wiring, at prescribed locations, must be bonded to a traction rail via a spark gap or similar device as detailed in EP 12 20 00 01 SP.

The overhead wiring structures at stations must be bonded to rail as per the following:

- Where passengers and/or the public are likely to contact the structure, including OHW structures at platforms and up to 10m beyond the ends of the platforms.
- Where important structures might otherwise be exposed excessively to corrosion (e.g. bridges).

Figure 1 Overhead wiring (OHW) structures, at prescribed locations, must be bonded to a traction rail via a spark gap.

Generally, most smaller stations in the system are appropriately bonded at overhead wiring structures, foot bridges and traffic bridges. Some of the larger stations, particularly those that have recently been upgraded, do not always conform to the required standards. This situation has generally arisen due to the piecemeal approach often adopted by the station upgrading work over the past decade. The scoping of this work did not always address the global implications of earthing and bonding.

At these more complex stations, some sections of awning have been built separately but are electrically joined by conductive elements such as metal guttering, downpipes, service lines, troughing and conduit. This poses a difficult situation to segregate the 1500V circuits from other parts of the station. Often the only option at these stations is to treat all metallic structures as one body which would involve the installation of additional bonding cables and a reconfiguration of the existing bonding.

This alternative, while not necessarily the best option, is considered the most pragmatic option for some situations due to the numerous platforms, stanchions, service lines, stairs, handrails, canopy supports and lighting columns involved. However, there are negative trade-offs with this option where the sphere of influence is greatly increased under fault conditions. Further, this option requires engineering analysis and bonding design to ensure the appropriate safety criteria is maintained.

Another safety issue concerning the proper installation and bonding of structures is the risk of causing a signalling failure due to incorrect configuration of spark gap bonds. This safety issue highlights the need for a proper detailed design approach, especially for larger complex stations.

EP 08 00 00 07 SP document sets out the design, construction and bonding requirements for safety screens on bridges and other structures located above or beside exposed 1500 V dc equipment.

There are instances where no bonding is present on safety screens where it is required, (as shown in figures 2 & 3) and there are instances where the methodology of the bonding connections is inconsistent.

Figure 2 Safety screen associated with a concrete footbridge where bonding is required

Figure 3 Note the insulation between the metal safety screens and the concrete bridge in accordance with RailCorp standards

Electrical insulation between the metal safety screens and the concrete reinforcement associated with the concrete bridges must be present. Further details are given in the Civil Design Drawing 160-801 “Electrical Safety Screens”.

Another issue is the proliferation of Anti-Throw Barriers (Anti-Projectile Screens) which are increasingly being installed on Overbridges. These metal screens can have major implications to the existing bonding

arrangements at Overbridges. These installations need to be assessed on a case by case basis for earthing and bonding determination.

5.2 Earthing

Examples of earthing issues are, but are not limited to:

- direct earthing system - isolation transformers
- main earthing conductor (earth bar to footbridge) minimum 16mm^2
- overbridge having low voltage cables in contact with the bridge connected to a 6 m electrode
- main earthing conductor (footbridge to earth electrode) 70mm^2
- interface between RailCorp's supply earth and other Network Operator supply earth
- issue of canopies under transmission lines

Railway stations in the electrified area employ a "direct earthing system". This system is applicable to electrical supplies sourced from either RailCorp's electrical system or alternative Supply Authorities. In more recent years, many station supplies have been transferred from RailCorp's electrical system to alternative supplies from either Energy Australia or Integral Energy. The situation has been exacerbated with the requirement of three phase supplies for lifts installed at stations under the Easy Access Programme. Under these circumstances, an isolating transformer is required to separate the station earthing from the Supply Authority's earthing system. The isolating transformer is connected between the local Electricity Distributor's service equipment and the supply main switchboard to physically isolate the earth and neutral of the MEN supply from any part of RailCorp's distribution system, including earthed metalwork (such as pipes, fences, overhead earth wires or troughing).

Any maintenance work or upgrading work must be monitored to ensure the interface conditions are not compromised. Isolating transformers can be effectively bypassed due to interconnections of the earthing systems via canopies or bus/rail interchanges. Electrical supply from different sources, for example lighting, can inadvertently bridge the earthing systems.

All Isolating Transformers must comply with RIC specification EP 17 00 00 11 SP "Low Voltage Isolating Transformers". In particular, attention is drawn to the nameplate requirements to readily ascertain compliance to the required specification.

When loadings at stations are substantially increased, corresponding higher fault levels are present. The earthing systems at stations may require upgrading in line with additional loadings. The assessment of the suitability and integrity of the existing earthing system must form part of any upgrading work.

Sometimes the main earth electrode is not visible at stations, posing major problems for ongoing maintenance and testing. This problem has often occurred due to the covering over of the station earth electrodes during station upgrading work.

Figure 4 Station main earth electrode is commonly housed in a concrete housing as shown. Note also the insulated water mains.

Documents EP 12 10 00 20 SP "Low Voltage Distribution Earthing" and EP 12 00 00 02 SP "Low Voltage Distribution and Installations Earthing References and Definitions" lists the publications and drawings relevant to earthing arrangements and other associated information.

Another pressing issue in relation to earthing and station upgrading is the hazard associated with many of the new canopies located under high voltage transmission lines. There is a safety risk to operational personnel or members of the public which arises from the danger of direct contact with a fallen overhead transmission line or indirect contact with touch voltages that may arise under fault conditions.

It is good policy not to build new canopies, buildings or other frequented structures under high voltage transmission lines. Document EP 12 10 00 22 SP "Buildings and Structures Under Overhead Lines" provides further details on this issue.

Figure 5 Avoid building new canopies, buildings or other frequented structures under high voltage transmission lines

This issue of structures located under high voltage transmission lines is currently being reviewed by RailCorp.

5.3 Separation issues

Examples of separation issues are, but are not limited to:

- metallic structures are physically separated by at least 2 metres distance from OHW structures
- canopy supports to be at least 2 metres from OHW structures
- lighting standards to be at least 2 metres from OHW structures
- lineside fencing to be at least 2 metres from OHW structures
- vending machines to be at least 2 metres from OHW structures
- ticketing machines to be at least 2 metres from OHW structures
- telephone booths to be at least 2 metres from OHW structures

There is a possibility that overhead wiring structures may rise to a potential above earth. A person could receive an electric shock when physical contact is made by touching overhead wiring structures at the same time as they touch lighting poles, metallic parts of canopies or awnings, steel troughing, metal fences or rolling stock.

The majority of the stations in the Metropolitan area adopt the policy of separation of the overhead wiring structures from other structures such as

roofs and buildings. Being in the vicinity of the general public, these OHW structures are normally spark gapped to rail in accordance with RIC policy document EP 12 20 00 01 SP “Bonding of Overhead Wiring Structures to Rail”. In doing so, any operation of the spark gap results in the structure being directly connected to rail with the resultant structure having a voltage present corresponding to the rail voltage. The rail voltage level is dependent upon many factors such as location, distance from the substation, train loadings and the characteristics of the rail and the overhead wiring. Under certain circumstances, this voltage can rise to potentially dangerous levels. However, the upper voltage limits are overseen by the rail earth contactor at Substation and Sectioning Huts.

Problems can exist on stations due to bonding arrangements of the overhead wiring structures. The most common problems are proximity of the overhead wiring structures to:

1. metal fencing,
2. metallic awning supports,
3. earthed metallic objects such as lighting standards, vending machines, water pipes, telephone booths, fire hydrant apparatus and CCTV's.

For situations where any of the separation criteria cannot be achieved, alternative options may be implemented to negate the separation issue.

Briefly, the possible alternative arrangements are:

1. Relocation

   The best electrical solution, although not the most economical solution, is to relocate all offending metallic supports to comply with the 2 metre rule of separation of two differing potentials.

Figure 6 Option 1 - Metallic supports to comply with the 2 metre rule of separation from OHW structure.

Figure 7 Option 4 - OHW structure isolation where the OHW stucture is enclosed by insulation material.

2. Limited Isolation

   This option attempts to limit the physical extent of conductive material which could be exposed to 1500 V fault current by segregation using appropriate insulated sections to ensure electrical discontinuity.
   This option has significant maintenance issues.

3. Interconnected metal mass.

   This option attempts to overcome possible touch potential problems by ensuring all metallic structures are electrically connected. However, this option can have negative trade-offs. 1500V fault current will have a wider area of influence and the resulting fault current path will be difficult to predict and manage.

4. OHW structure isolation

   This option uses the concept of double insulation to effectively isolate an OHW structure section from the remaining sections of the structure.
   This option has significant cost impacts as well as ongoing maintenance and surveillance issues.

The best option which overcomes the majority of earthing and bonding issues is option 1, which uses the principle of separation. Obviously, in installations where this separation is compromised, it can be an expensive exercise to either relocate all offending metallic supports or revert to other alternatives.

It is stressed that the most cost effective and safest configuration for any new canopy or building work is to incorporate the principle of separation into the design stage. If earthing and bonding issues are integrated into the design stage, substantial cost savings can be achieved as well as drastically reducing the risk exposure to persons and property.

This process of “designing out” earthing and bonding issues must be an essential outcome for RailCorp to safeguard itself against risk of damage, fire, electric shock or loss of life.

Figure 8 Example of poor design where the new canopy supports are in close proximity to the existing OHW structure.

Many stations suffer from the problem of close proximity of overhead wiring structures to fencing. The typical fencing encountered on many stations is the powder coated pool style fencing which can run along either a section of the station platform or the total length of the platform.

Figure 9 Close proximity of fencing and lighting standard to the overhead wiring structure. Note the CCTV metal conduit at bottom of fence bridging any isolation gaps if present.

Figure 10 Correctly installed fencing with two separate isolation gaps placed at least two metres on either side of the OHW structure.

On some stations, the fencing has been properly installed by creating two separate isolation gaps placed at least two metres on either side of the OHW structure as shown in Figure 10. However, there are many instances where contractors have bridged these gaps with metal conduit, usually used in the installation of extra lighting, water pipes or CCTV's. The appropriate remedy for such situations is the replacement of the metal component across the gap with a non-conducting enclosure with suitable mechanical protection.

Considerable problems exist at many stations where station upgrading work has installed canopy awnings on platforms and station concourses. Typically, many of these projects were design and build tenders, with the designer not always taking into account the separation issues associated with earthing and bonding. Consequently, large amounts of contingency work have been required over the last few years to correct many of the problems at stations. The most common problem is the close proximity of metallic awning supports relative to overhead wiring structures where metallic awning supports are within the two metre separation distances.

Figure 11 Awning supports within 2 metres of OHW structures.

This situation poses a potential voltage difference between the two structures and is a safety risk to operational personnel or members of the public.

Another problem at stations is where an overhead wiring structure protrudes through the roof without sufficient clearance from the structure to the roofing. A gap of at least 50 millimetres is required to ensure electrical separation of the two structures, otherwise arcing can occur in the event of a spark gap failure. At a number of locations, the installation of non-insulating flashing has occurred to eliminate the ingress of rain, thus bridging the gap and creating an undesirable current path.

Figure 12 Overhead wiring structure protruding through the roof without sufficient clearance

Figure 13 Example of unacceptable installation using non-insulating flashing.

This situation is unacceptable. If the spark gap blows, the traction return current would flow through the metal roof and in turn flow through the low voltage lighting circuit with the possibility of an electrical fire and resultant collateral damage to the station.

This situation can be corrected by ensuring a gap of at least 50mm surrounding each structure. If required, the resultant gap could be filled in by insulated sheet flashing such as polycarbonate to seal against the weather.

Figure 14 Example of acceptable arrangement showing insulated sheet flashing and surrounding gap to the OHW structure.

Figure 15 Example where roofing material is in direct contact with the overhead wiring structure

Another common problem is where roofing renewal has occurred and either the roofing supports or the roofing material are in direct contact with the overhead wiring structure. This situation is unacceptable, as shown in Figure 15.

Figure 16 OHW structure in close proximity to vending machines

A touch potential problem can exists where the OHW structure is in close proximity to vending machines.

The arrangement at Figure 16 presents vending machines at low voltage earth potential within 2 metres of the OHW structure. Persons could bridge themselves between these two conductive components at differing potential.

To remedy this situation, the vending machines should be relocated at least 2 metres away from the structure.

Touch potential problems can also exist where the stanchion is in close proximity to a Telstra phone booth.

Figure 17 OHW structure in close proximity to Telstra phone booth

Figure 18 Unistrut in contact with the canopy support and the fire hydrant service pipe

This arrangement presents the phone booth at low voltage earth potential that is within 2 metres of the stanchion. Persons could bridge themselves between these two conductive components at differing potential.

5.4 Isolation issues

Examples of isolation issues are, but are not limited to:

- isolation of boundary fence to station fencing
- signalling troughing – appropriate insulated sections
- isolation of all incoming metallic service lines - water, gas, fire service, telephone, sewerage, stormwater/downpipe etc
- any introduced electrical supplies - isolation transformers
- any interface between RailCorp's supply and other Network Operator supply

- CCTV implications: metallic conduit runs, video cable connections

Document EP 12 10 00 21 SP “Low Voltage Installations Earthing” details the earthing and bonding requirements of various types of low voltage installations located on the `railway corridor' and `near 1500 V track'.

Where a railway station interfaces with another building or structure, such as a bus rail interchange or a footbridge that connects a railway station with a shopping centre, the design shall not allow the extension of RailCorp’s low voltage earthing system beyond the railway corridor. This includes all metallic structures and services, such as awnings, fences, pipes and electrical wiring and conduits. The interface should be well defined and easily observable. This is usually achieved by installing two isolation 'gaps' in the steelwork, about 2m apart.

Figure 19 Example of a footbridge that connects a railway station. The design shall not allow the extension of RailCorp’s low voltage earthing system beyond the railway corridor

Problems occur where isolation points have been bridged by either conduits or other circuits. Situations have occurred where the installation of the CCTV has bridged out the isolating sections separating the station supply from another separate Supply Authority supply, such as a station car park. These situations require constant surveillance to ensure the isolation is not compromised. Too often contractors and other associated parties performing work on stations are not aware of these issues.

Figure 20 Example where the isolation point between two sections of canopy has been bridged by modified guttering.

Bus/rail interchange situations often require major modifications to canopies and roofing to overcome the isolation problems. These post-construction modifications and associated major expenses could be minimised if the designs for station upgrading were scrutinised prior to construction to capture any potential problems. Many stations have been compromised where the best technical solution has not been able to be implemented due to the major modifications and costs involved. Instead a less desirable alternative to overcome touch potential issues has had to be implemented at certain locations.

In addition, due to the interaction of the low voltage electrical supply to stations (ie light fittings associated with awnings or canopies) and the proximity of 1500 V overhead wiring structures, special analysis for each station is required to minimise the risk of electric shock and also combat the effects of electrolysis associated with a DC traction system.

Another common problem effecting stations is the inter connection of the Railway boundary fence to station fencing. This situation can contribute to the electrolysis problems associated with the traction system. On many stations, additional metallic fencing panels and fencing wire have been added at the ends of platforms to prohibit illegal access.

Figure 21 Example showing inter-connection of the Railway boundary fence to station fencing

Again, isolation sections should be installed at the fencing interface or at an appropriate location in close proximity to the station. These fencing issues are canvassed in document C 4501"Metallic Lineside Fencing in Electrified Areas".

Additionally, appropriate insulated sections must exist for metal signalling troughing, in accordance with RIC standards.

Another issue becoming more prevalent is the installation of metal coping edges along station platforms. Depending on the installation method, this configuration can have earthing and bonding issues, especially where appropriate isolation is not present. Instances have been reported (Circular Quay) where severe arcing has taken place when wheel chair accessibility ramps have been placed on the platform where metal coping exists.

A major concern is the seemingly omission of isolation joints for incoming metallic service lines onto the rail corridor. These isolation joints are essential to ensure the segregation of the railway earthing to the service lines to minimise the affects of electrolysis. Isolation joints for services such as gas, water, fire services, etc. must be visible for inspection and/or have appropriate signage in accordance with RIC standards, including. EP 12 30 00 01 SP "Electrolysis From Stray DC Current".

Figure 22 . Isolation joints for services such as gas, water, fire services, etc. must be visible for inspection and/or have appropriate signage.

Another major issue coming to the fore is the proliferation of CCTV cameras on stations which has the potential to cause fire and collateral damage.

Figure 23 Black flexible metal conduit bridging the two structures which are designed to be electrically separated

Incidences have occurred where the metal conduit housing the coax cable for the CCTV's has breached separate sections of canopies causing the cable to melt, resulting in a roof fire eg. Epping Station.

Figure 24 Example where CCTV metallic conduit has bridged out isolation sections.

Often, the CCTV installation has compromised the isolation requirements on stations where metallic conduit has bridged out isolation sections. Some initial discussions on these matters have been held with State Rail on installation methods required at stations.

6. Conclusion

Earthing and bonding issues at railway stations are predominantly attributed to the interface issues between overhead wiring structures, awnings or canopies and services entering the rail corridor.

The most common problems are related to the bonding arrangements associated with overhead wiring structures in close proximity to:

- metallic awning supports,
- metal fencing,
- earthed metallic objects such as lighting standards, vending machines, water pipes, telephone booths, fire hydrant apparatus and CCTV's.

Generally, most stations in the electrified system are appropriately bonded at overhead wiring structures, foot bridges and traffic bridges. Spark gaps are an essential safety device and are critical to the 1500V traction system protection and bonding scheme. As such, any maintenance or construction work involving these items should be carried out in accordance to RailCorp's policy requirements.

Another common problem effecting stations is the interface of the railway boundary fence to station fencing. This situation can contribute to the effects of electrolysis. Some of these defects are attributable to additional metallic fencing panels and fencing wire installed to prohibit illegal access at the ends of platforms and the lack of an isolating panel or isolation sections of fencing.

Many stations have situations where interface issues between RailCorp's supply earth and another Network Operator supply earth apply. At these locations, any maintenance work or upgrading work must be monitored to ensure the interface conditions are not compromised. It is recommended that appropriate signage would be beneficial to alert contractors and other personnel to this issue. Additionallly, installation of radiating services such as CCTV must be carefully designed and controlled to ensure isolation sections are not bridged.

Issues such as high voltage transmission lines sited above sections of station canopies or roof areas must also be monitored when planning any upgrading work.

Another safety issue concerning the proper installation and bonding of structures is the risk of causing a signalling failure due to incorrect configuration of spark gap bonds. This safety issue highlights the need for a proper detailed design approach, especially for larger complex stations.

The siting of services on stations such as vending machines, ticketing machines, telephone booths, water taps, etc must be considered in relation to earthing and bonding principles.

With the further roll out of station upgrading projects, the issues associated with railway station interfaces with other buildings, structures, bus-rail interchanges etc will become more prevalent. Greater control over this work is crucial to ensure RailCorp's standards are met in future.

Past deficiencies in relation to earthing and bonding are due to the piecemeal approach often adopted by the station upgrading work. Projects must not limit their scope to their own upgrading work without addressing the global implications of earthing and bonding.

At more complex stations, some configurations pose a difficult situation to segregate the 1500V circuits from other parts of the station. Often the best compromise option at these stations is to treat all metallic structures as one body. This alternative, while not necessarily the optimal option, is considered the most pragmatic option for some situations due to the numerous platforms, stanchions, service lines, stairs, handrails, canopy supports and lighting columns involved. However, there are negative trade-offs with this option where the sphere of influence is greatly increased under fault conditions. Further, this option requires engineering analysis and bonding design to ensure the appropriate safety criteria is maintained.

It is emphasised that appropriate configuration documentation for earthing, bonding and electrolysis mitigation equipment is essential to minimise the risks associated with these issues. This configuration documentation must be incorporated into any new project involving upgrading work to ensure integrity of the assets and allow for maintainability.

It is evident that there is no simple formula for solving existing problems, especially at more complex stations. In these situations, each station must be assessed on its own merit, taking into consideration the existing configuration and the proposed work to determine the best optimal solution, culminating in the production of an earthing and bonding design.

The principle of separation is the best option that overcomes the majority of earthing and bonding issues, especially for limited new work. Obviously, in existing installations where this separation is already compromised, it can be an expensive exercise to either relocate all offending metallic supports or revert to other alternatives.

From a risk management perspective, the process of "designing out" earthing and bonding issues must be the first choice in the hierarchy of managing these risks. This is especially so in relation to proposed new upgrading work.

It is stressed that the most cost effective and safest configuration for any new canopy or building work is to incorporate the principle of separation, if feasible, into the design stage. If earthing and bonding issues are integrated into the design stage, substantial cost savings can be achieved as well as drastically reducing the risk exposure to persons, property and RailCorp.

APPENDIX 1

The following are selected extracts from relevant RIC (RailCorp) documents dealing with railway station earthing and bonding requirements. The extracts are not a comprehensive set of documentation but have been compiled to concisely highlight the major issues associated with earthing and bonding.

EP 12 10 00 21 SP
Low Voltage Installations Earthing

1.1. Clearances from 1500 V Structures and Other Earthed Metalwork

A 2 m distance shall be maintained between the earthing system of the low voltage installation, including earthed metalwork for example fences, vending machines and telephone cabinets, and any overhead wiring structures which are not bonded to the same earthing system or metalwork connected to a separate earthing system.

1.6. Lineside Metal Fencing or Signal Troughing

A 2 m clearance must be maintained between any metal connected to the railway stations low voltage earth and any continuous metal structure, such as a fence or signal troughing, that is not intentionally connected to the earthing system. Where the 2 m clearance cannot be obtained, a suitable approved method such as installing two isolating breaks 2 m apart in the continuous metal structure shall be used. Alternatively the situation can be proved safe by calculation and testing for dangerous touch voltages in accordance with the ESAA Substation Earthing Guide.

1.7. Metallic Conduits

In general metallic conduits are not permitted to be installed underground or in concrete within the electrified area due to the presence of stray 1500 V dc leakage currents. However, in practice short lengths should not present a problem, therefore, if a situation arises where a short length of buried metallic conduit is the preferred method then the definition of appreciable dc leakage current from Specification EP12000002SP - "Low Voltage Distribution and Installations Earthing References and Definitions" can be applied

2. Overbridge having 1500 V Overhead Wiring and Low Voltage Wiring Attached

2.1. Connection to Electrode

An overbridge at any railway station in the electrified area having low voltage cables in contact with the bridge will require the bridge to be connected to a 6 m electrode using a 70 mm² copper conductor, refer to section 2.1.1. The electrode is to be located as close as possible to the bridge and installed as detailed in sections 2.1.2 and 2.1.3. The 70 mm² conductor shall be protected against mechanical damage as detailed in

section 1.5 and be secured to the over bridge by no lesser security than a crimped closed lug, lock-nutted onto a stud of minimum size 12 mm.

3. Railway Station Interfaces

Where a railway station adjoins with another building or structure, such as a bus rail interchange or a footbridge that connects a railway station with a shopping centre, the design shall not allow the extension of the RIC low voltage earthing system beyond the railway corridor. This includes all metallic structures and services, such as awnings, fences, pipes and electrical wiring and conduits. The interface should be well defined and easily observable and where any doubt exists the situation shall be proved safe by calculation and testing for dangerous touch voltages in accordance with the ESAA Substation Earthing Guide.
The metalwork of the structure that has been isolated from the station may be connected to an MEN earthing system.

C 4501
Metallic Lineside Fencing in Electrified Areas

When constructing metallic fencing along the 1500V DC electrified rail corridor, the following key electrical aspects must be considered:

- The transfer of touch and step potentials along the metallic fencing, and
- The mitigation of electrolysis.

EP 12 30 00 01 SP
Electrolysis From Stray DC Current

1 Introduction

….Ideally, all current should return through the rails, but since they are in close contact with the ground through the sleepers and ballast, some current will 'leak' from the rails and return to the substation through the ground. This is called 'stray current' or 'leakage current'…..

…..The problem of minimising electrolysis is closely related to the problem of earthing and/or bonding of metallic structures to prevent electric shock to people. The solutions to both problems have to be a compromise since the 'best' solution for one situation results in major problems for the other situation.

5 Minimisation Techniques

The following minimisation techniques are recommended for any person engaging in work within the `railway corridor' and near `1500 V track'. All mandatory requirements are covered in relevant documents.

- Overhead wiring structures which are bonded to rail via a spark gap do not contact earthed services such as station awnings, fences, water pipes etc.

- In tunnels, on bridges and under air-space developments, there is no contact between rails and reinforcing or other steelwork.
- Keep metallic services 'away' from the track so there is less chance of 'picking up' appreciable dc leakage current.
- All low voltage supplies use Isolating transformers. Local Electricity Distributor neutral and earthing systems should not enter Railway Corridor.
- Water and Gas pipes servicing buildings on the Railway Corridor and near 1500 V track to have an isolating joint installed at the boundary.
- Fencing at stations and electrical substations is not to be connected to the lineside fencing.
- Ensure all metallic structures such as footbridges, bus shelters etc. are isolated at boundary of Railway Corridor. This is usually achieved by installing two 'gaps' in the steelwork, about 2m apart. Special care is needed if there is lighting installed, to ensure the local Electricity Distributor's earth is not connected to the steelwork which forms part of any overhead wiring structure, station or bridge.

EP 12 10 00 22 SP
Buildings and Structures Under Overhead Lines

1. High Voltage Transmission Lines

Where a building or structure is located such that possible risks could arise due to induction, touch or step voltages, infringement of safety clearances to conductors, or the failure of line materials or structures, the earthing system of the building or structure shall meet the requirements of the Electricity Council of NSW document EC 20 - "Guidelines for the Management of Electricity Easements".

EP 12 00 00 02 SP
Low Voltage Distribution and Installations Earthing References and Definitions

This document lists the publications and drawings that are referenced in associated documents and can provide extra background information.

EP 12 10 00 20 SP
Low Voltage Distribution Earthing

2. Supply from Local Electricity Distributor's Network

2.1. General

The MEN system of a local Electricity Distributor must not be allowed to pick up appreciable dc leakage current. The recognised method of achieving this is to ensure the earth and neutral of the MEN supply is physically isolated from any part of the supplied installation, including earthed metalwork (such as pipes, fences, overhead earth wires or troughing).
This document is based on the use of an isolating transformer to separate the local Electricity Distributor's MEN earth and neutral from the RIC distribution systems direct earthing system……..

2.3. Isolating Transformer

An isolating transformer shall be connected between the local Electricity Distributor's service equipment and the supply main switchboard to physically isolate the earth and neutral of the MEN supply from any part of the RIC distribution system, including earthed metalwork (such as pipes, fences, overhead earth wires or troughing).
The isolating transformer shall comply with SRA Specification A-844 (now RIC specification EP 17 00 00 11 SP). The transformer shall be installed with a sign prominently displayed on its case stating that it is double insulated and conforms to AS 3108…….