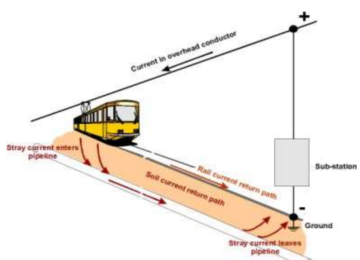
Cathodic Protection Services

Electrolysis & Stray Traction Current Report

DORAN DRIVE PRECINCT
CASTLE HILL



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Report No: A715-498-293
Revised May 26, 2021
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** TABLE OF CONTENTS **

Appendix:

A: Corrosion by Stray Traction Current

B. Insulating Flange Kits

C. NSW Government, Transport for NSW: T HR EL 12002 GU
Guide, "Electrolysis from Stray DC Current", Version 1.0, dated 1 May 2014

D. Sydney Metro Guidelines

1. INTRODUCTION

Construction of a mixed use Development is proposed for Doran Drive Castle Hill.

The elimination of corrosion hazards from stray traction current involves increasing the resistance of the conductive path for stray current which may otherwise be conducted into the underground sections of the structure. If stray current is conducted into the structure, severe corrosion of the concrete reinforcement can result, ultimately resulting in structural failures.

It is a requirement of Trains for NSW and Sydney Metro that for all Developments in the vicinity of electrified tracks a report is developed identifying what measures should be taken to ensure stray traction current does not present a corrosion hazard to the proposed development.

Cathodic Protection Services were commissioned to;

a. Review the development plans and possible exposure to stray traction current and prepare a report to eliminate any such hazards.

b. Provide an opinion on whether stray traction current presents a corrosion hazard to the proposed development, and what, if any, remedial or mitigation actions are necessary to eliminate the hazards.

2. CONCLUSIONS

The conclusions of this investigation are;

2.1 Stray traction current can be expected to be present on the site of the Development

2.2 The proposed method of construction, as outlined in Clause 4 of this report will essentially prevent the entry of stray traction current into the structure.

2.3 Corrosion of the water service or the electrical earth can be caused by stray traction current. Installation of an insulating fitting in the water service, or the use of a non metallic water meter, or PVC pipe eliminates this hazard.

2.4 Data Logging to identify the stray traction current signature across the site both prior to any development work, and at the conclusion of the construction is required as nominated in Clause 6.9 of Sydney Metro Technical Services Guidelines, September 2018.

3. CODES AND STANDARDS

This report has been developed taking into account of the following;

i. T HR EL 12002 GU- "Electrolysis from Stray DC Current"
Version 1.0 dated 1 May 2014

See attachment, Appendix C

ii "Guide for Measurement of Interference Caused by Cathodic Protection and Railway Drainage Systems" Office of Energy, 1998.

iii. Sydney Metro – Technical Services
'Sydney Metro at Grade and Elevated Sections
Corridor Protection Guidelines

4. 2 MANDALA PARADE CASTLE HILL

Construction of a retail/residential Development is proposed for Castle Hill. The Development will have 20 above ground levels and 6 underground levels. The site is north of the Metro Tunnel and Mandala Parade, east of Doran Drive and west of Andalusian Way.

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Details of the construction of the development are shown on the following ABC Consultants Drawings. Also provided are comments on the implications to the foundations of the structure as a consequence of stray traction current.

DRAWING NO	REVISION	TITLE
S01.101	P1	SITE RETENTION NOTES
S01.105	P1	SITE RETENTION PLAN

Details of the construction are outlined below;

4.1 ONGROUND SLAB

The lower basement onground slab will be cast on a moisture barrier.

The moisture barrier acts as an electrical insulator to the conduction of stray traction current.

4.2 FOOTING

Pad and strip footings will be provided at load bearing areas Concrete strength is specified at a minimum of 32 MPa with 50 mm of cover.

Concrete with a minimum strength of 32 MPa combined with a minimum off 50 mm of clear concrete cover is considered to have sufficient electrical resistance to reduce conduction of stray traction current. The footings comply with these requirements

4.3 PILES

The excavation will be supported by 600 and 900 diameter reinforced concrete soldier piles. Concrete strength is nominated as 40 MPa with 70 mm of clear concrete cover.

Concrete with a nominated strength of 32 MPa or greater, combined with a minimum cover of 50mm is considered to have sufficiently high electrical resistance to prevent

The conduction of stray traction current. The concrete for the piles comfortably exceeds these values

4.4 SHOTCRETE WALLS

The area between the piles will be infilled with reinforced shotcrete. The shotcrete is specified at 32 MPa with 70 mm of cover on the ground side. The reinforcing fabric will be secured by 16 mm steel dowels epoxy resined into the piles. The reinforcing fabric is installed in discrete sheets and is not continuous from pile to pile.

> Again the concrete specification exceeds the minimum cover to resist conduction of stray traction current. Additionally, as the reinforcing fabric is in discreet sections, this will prevent conduction of stray traction current longitudinally along the wall.

4.5 RETAINING WALLS

Both reinforced blockwork and brick retaining walls will be provided. A moisture barrier is specified on the ground side of all retaining walls.

> Again, the moisture barrier will prevent conduction of stray traction current into the structure.

4.6 GROUND ANCHORS

There will be no ground anchors.

4.7 INCOMING SERVICES

Stray traction current can affect metallic water, fire and gas services. Should stray traction current be picked up by the services, this can result in a corrosion problem on;

a. The services.

b. The Development's electrical earth system. This is because the earth and the water service have a direct interconnection via the MEN system. Current picked up by the water and/or fire services can discharge back to the earth via the earth system resulting in corrosion of the earth grid or stake.

The above corrosion hazard to water and fire services can be eliminated by installation of an insulating fitting, or non-metallic sections in the water and fire services at or close to the boundary of the property as detailed in the Transport for NSW document T HR EL 12002 GU “Electrolysis from Stray DC Current”, Clause 5.3.

> *“Water and gas pipes servicing buildings on the Railway Corridor and near 1500 V track to have an isolating joint installed at the boundary.”*

Suitable insulating fittings are available from Corrosion Control Engineering, telephone 9763 5611.

Gas services do not require any insulation. If the service is metallic construction, this will be fitted with a cathodic protection system incorporating an insulating joint at the meter. If the service is low pressure, this will be run in non metallic pipe.

4.8 DATA LOGGING

Clause 6.9 of Sydney Metro Technical Services Guidelines, September 2018 nominates that data logging shall be undertaken to identify the stray current signature across the site prior to any construction work, and at the conclusion of the work to identify that amitigation strategies have been effective.

PLEASE NOTE:

The following sections are provided for information only and do not necessarily apply to this project.

5. THE PROBLEM OF STRAY TRACTION CURRENT

5.1 BACKGROUND

Sydney Trains use 1500 volt direct current to operate the traction system. The current is delivered by the overhead catenary cables and the return path to the sub station is via the track. The track has low resistance earth, principally because of the difficultly of achieving insulation

Whilst the steel track is large in cross section, some of the current can leak from the tracks and finds alternate paths back to the sub station. Considerable current can be involved. As an indication, a Tangara train requires about 4000 amps to start from rest.

All current obeys Ohms Law and if a low resistance metallic structure exists in the path ofthe “stray” current this can pick up the stray current which then flows along the structure to a point close to the sub station, where it leaves the metallic structure and enters the earth.

Where the “foreign” structure picks up the stray current a small measure of corrosion control or “cathodic protection” is achieved. However, where the current discharges from the foreign structure back to the soil, corrosion of the foreign structure occurs as shown on Sketch CP34.

The problem of stray current corrosion was first identified in the 1930’s. For stray current to be a serious problem the foreign structure has to be electrically continuous.

At that time the only organisation which had electrically continuous structures were the PMG (now Telstra) with their lead sheathed cables. They suffered corrosion failures and for many years considered this to be a necessary evil. However an enterprising Engineer decided to plot failures on a map and found they were predominantly grouped round rail lines or tram lines. Further investigation showed that they were also grouped around the sub stations associated with the tracks. He eventually identified the corrosion problem.

The PMG (now Telstra) sought compensation from the Railways for the corrosion damage caused by the stray traction current. The Railways did not receive this approach well and it did appear that the Federal Government would be suing the State Government.

Whilst this was occurring the Engineering staff developed a solution to the problem. This was to connect the foreign structure to the tracks via a simple control system. This provided a low resistance path for the stray current to return to the tracks thus eliminating the corrosion problem. The control bond could be engineered such that a degree of additional corrosion protection could be provided to the foreign structure.

The above led to the formation of the Electrolysis Committee which has representatives of the owners of all underground services, and Sydney Trains. Cathodic Protection Services represents the interests of the Oil and Chemical Industry on the Committee. Apart from the War Years the committee has met at about monthly intervals since the 1930's to discuss stray current problems and its mitigation with the Railways.

5.2 CORROSION HAZARD FROM STRAY TRACTION CURRENT

Direct current as used by the traction system can cause serious corrosion to underground metallic services and the steel reinforcement of concrete. Stray traction current flowing in the ground can be picked up by the steel reinforcement one side of the development, flow along the steelwork and discharge back to the soil on the opposite side of the building. At the discharge point of the current, corrosion of the reinforcement will occur.

For a building, the most common means of eliminating the corrosion hazard from stray traction current is to increase the electrical resistivity of the concrete to the ground. This reduces the flow of stray traction current through the reinforcement.

Increasing the electrical resistance of the structure to ground for an onground slab is automatically achieved by the moisture barriers installed to prevent water entry into the structure. The moisture barrier is an electrically insulating membrane.

Where the structure is supported on pad and/or piered footings, increasing the resistance of the structure to ground can be achieved by either;

a. Applying moisture barrier to the excavation into which the pad footings or piers are poured.
b. The electrical resistance of concrete increases as the strength of the concrete increases. Concrete with minimum strength off 32 MPa and 50 mm of clear concrete cover is considered to have adequate electrical resistance to resist conduction of stray traction current.

6. DETECTION OF STRAY TRACTION CURRENT

Stray traction current can be identified by either;

- Measurement of the potential of a metallic structure [such as a water service] to a reference electrode over a 24 hour period.
- Measurement of the potential gradient across the development to earth stakes over 24 hours.

Fluctuations in the potential values indicate the presence of stray traction current.

Sydney Trains requirement does not include identification of the presence of stray traction current. If the Development is on a corridor reserved for a future rail system, an electrolysis report is still required. The purpose of the Electrolysis Report is to ensure the design of the Developments foundations are such that the foundations are protected from corrosion hazards from stray traction current.

7. MITIGATION OF STRAY CURRENT

There are a number of options to deal with the potential corrosion problems which can result from stray traction current. These include,

a. Prevent or reduce exposure of the structure to stray traction current.
b. Install a mitigation system to offset the problem.

In the case of the latter this is an expensive approach as it requires the establishment of infrastructure necessary for the mitigation of the problem.

7.1. ELIMINATE OF REDUCE EXPOSURE TO STRAY TRACTION CURRENT

The simplest approach is to avoid exposure of the structure to stray traction current. Two approaches, which can be adopted, are;

7.1.1. Reduce Length of Structure in Alignment with Traction Current Path.

As noted in Section 6, the hazard from stray traction current is due to the current flowing onto and then off the metallic structure. Corrosion occurs at the point of discharge of the current back to the soil.

The hazard from the stray traction current increases as the length of the conducting service increases. Stray traction corrosion is a problem because the

metallic service presents a lower electrical resistance path to current flow than the alternative path through the earth.

For current to flow onto and discharge from an underground structure, electrochemical reactions need to occur to generate or absorb electrons. Both these reactions require energy, which results in a resistance existing between the structure and the earth. If the structure is short in length, the combined resistance of the pick up and discharge reactions is sufficient to reduce the traction current flowing onto the structure.

Additional to the above, the passage of the stray traction current causes development of potential gradient in the earth. For a short metallic conductor, the potential gradient to which it is exposed to too small to allow the pick up of the current.

Accordingly the shorter the length of the metallic structure the less likely it is to be affected by stray traction current.

7.1.2. Isolate the Structure from Stray Traction Current.

The effects of stray traction current can be avoided by increasing the resistance of the structure to the soils in which stray traction current is flowing. This can be achieved by use of moisture barriers such as FORTICON which provides an electrically insulating membrane which prevents entry of stray traction current. Even if the membrane is damaged, it will still provide sufficient resistance to prevent entry of stray traction current.

7.1.3. Use of High Strength Concrete.

Increasing the strength of the concrete increases the electrical resistance of the concrete. Thus if concrete of 32 mpa is used for the underground components, this has a high resistance, due partly to the reduced water content, and acts as an electrical insulator to the entry of stray traction current.

7.2 STRAY TRACTION CURRENT MITIGATION

Stray traction current mitigation is achieved by providing an intentional low resistance path from the structure to allow flow of any stray traction current directly back to the rail.

Provision of a mitigation system involves the following;

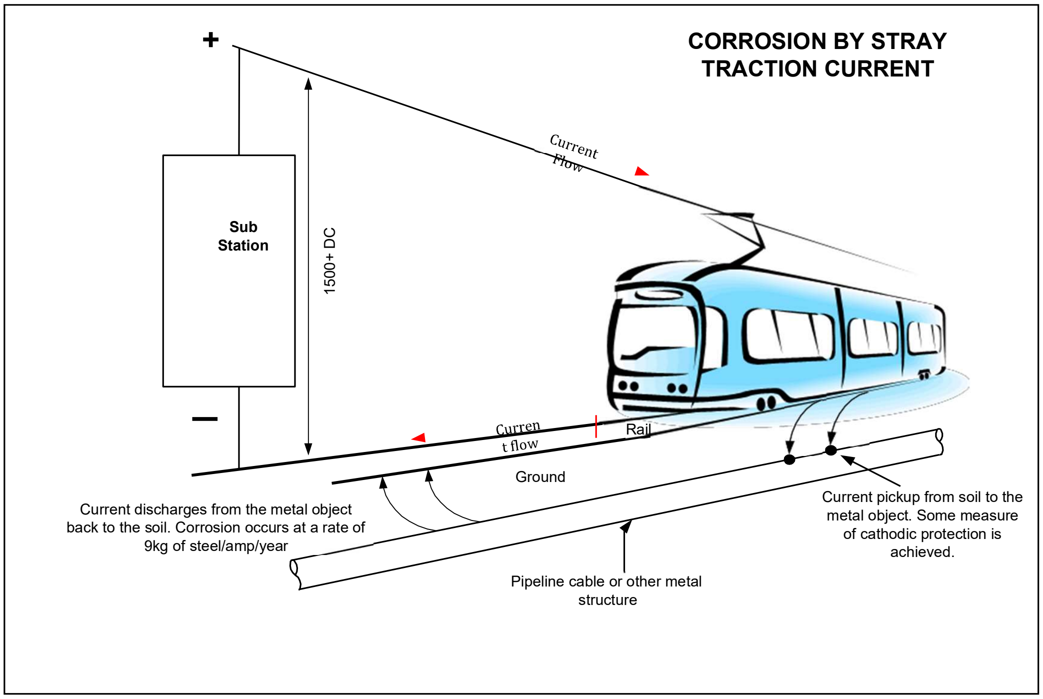
a.. Testing has to be undertaken to provide evidence to the Railways that a stray traction current corrosion hazard exists.

b. If the testing identifies a corrosion hazard to the steel reinforcement does exist, installation of a “railway drainage bond” can proceed.

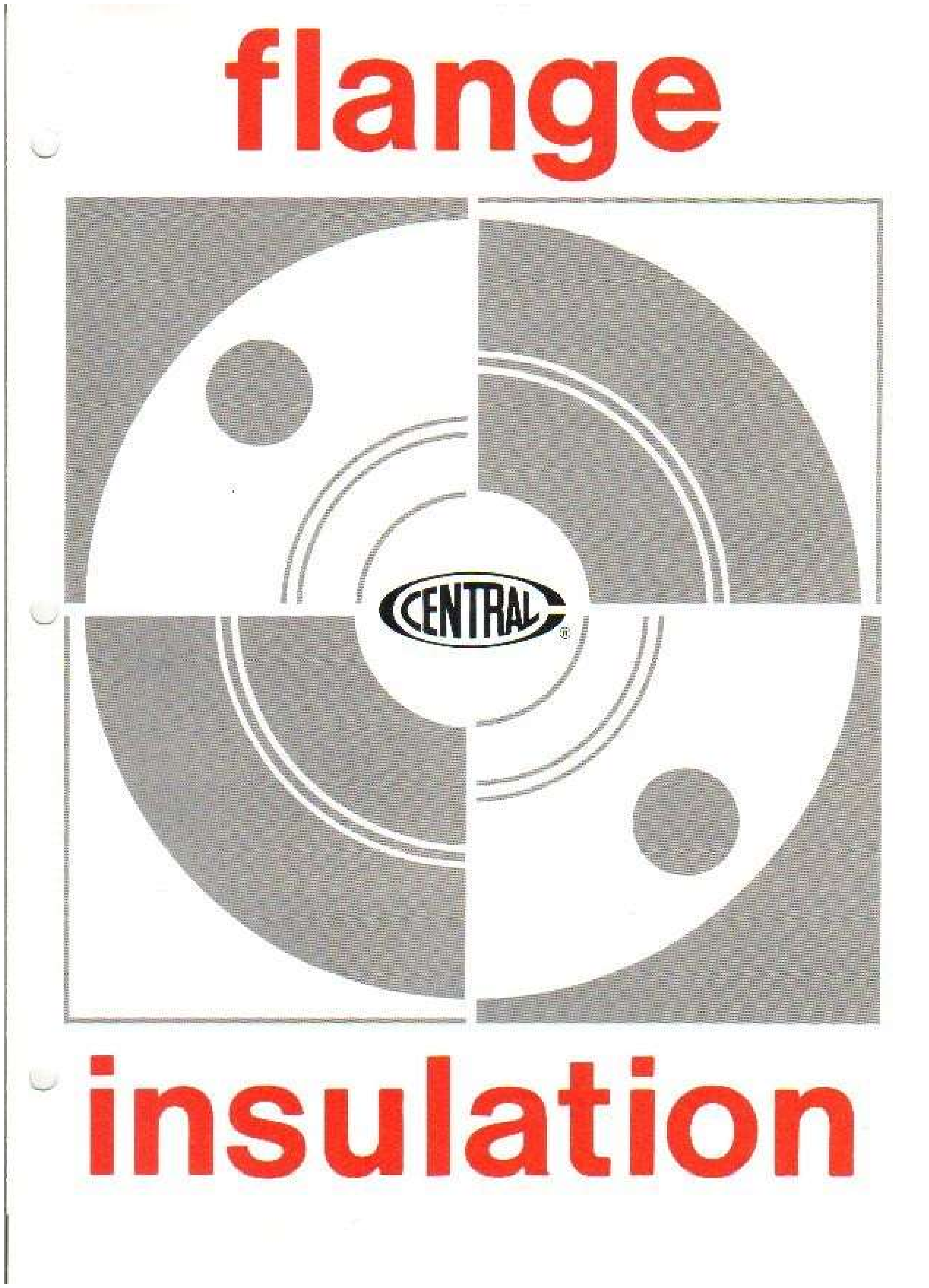
It is appreciated that installation of a mitigation system is a particularly expensive option. The only building projects on which Cathodic Protection Services have recommended a stray traction mitigation system are;

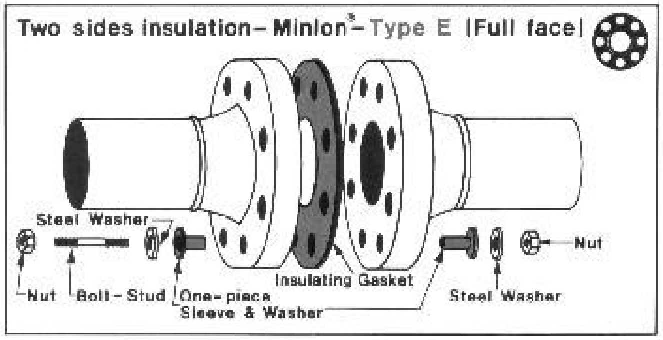
- The Sydney Harbour Tunnel. This structure is 3200m in length and testing indicated the existence of a stray traction current hazard.
- Chatswood Connection project. This development by Girvan was over one km in length and provision for a stray traction current mitigation system was designed into the proposed project. Unfortunately Girvan went into receivership in the early stages of the project.

APPENDIX A

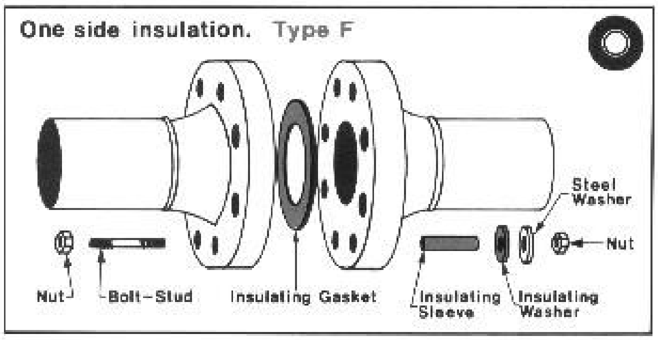

CORROSION BY STRAY TRACTION CURRENT
+
Sub Station
1500+ DC
Current Flow
Curren t flow
Rail
Ground
Current discharges from the metal object back to the soil. Corrosion occurs at a rate of 9kg of steel/amp/year
Current pickup from soil to the metal object. Some measure of cathodic protection is achieved.
Pipeline cable or other metal structure

APPENDIX B



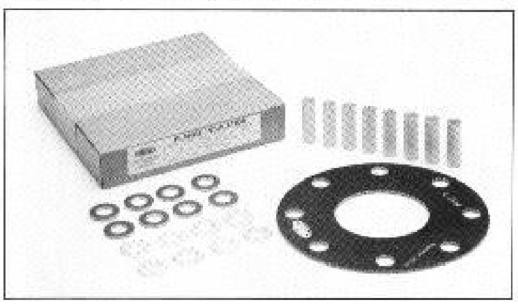


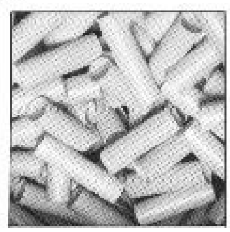
Type "E" gaskets perfectly center on precisely located bolt holes. Since their outside diameters are the same, foreign material is prevented from "shorting" the flange insulation



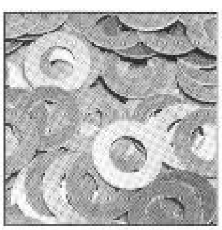
Type "F" gaskets are made without bolt holes, to fit tightly inside the overall bolt hole circle of the flange faces. The outside diameter of the gasket fits tightly in place assuring a well centered position.

FLANGE INSULATION KIT

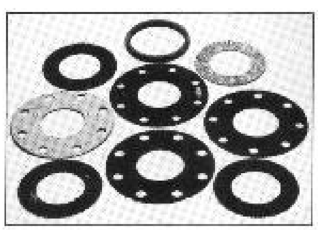




INSULATING SLEEVES
- POLYETHYLENE
- MYLAR
- PHENOLIC
- EPOXY GLASS
- OTHERS



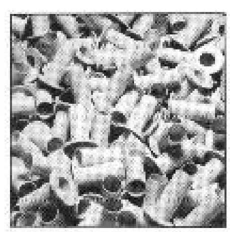
INSULATING WASHERS
- PHENOLIC
- EPOXY GLASS
- OTHERS



INSULATING GASKETS
- TYPE E – FULL FACE
- TYPE F – RING
- TYPE D – RTJ, BX
- Jack-O-RING

NEOPRENE FACED PHENOLIC
PHENOLIC
J.M. 71® ASBESTOS
EPOXY GLASS
OTHERS

SEAL RING
- NITRILE, BUNA-N
- VITON
- OTHERS



MOLDED ONE-PIECE SLEEVE & WASHER
- MINLON®

(Standard Gasket Width - 1/8")

FOR BEST RESULTS
CENTRAL RECOMMENDS

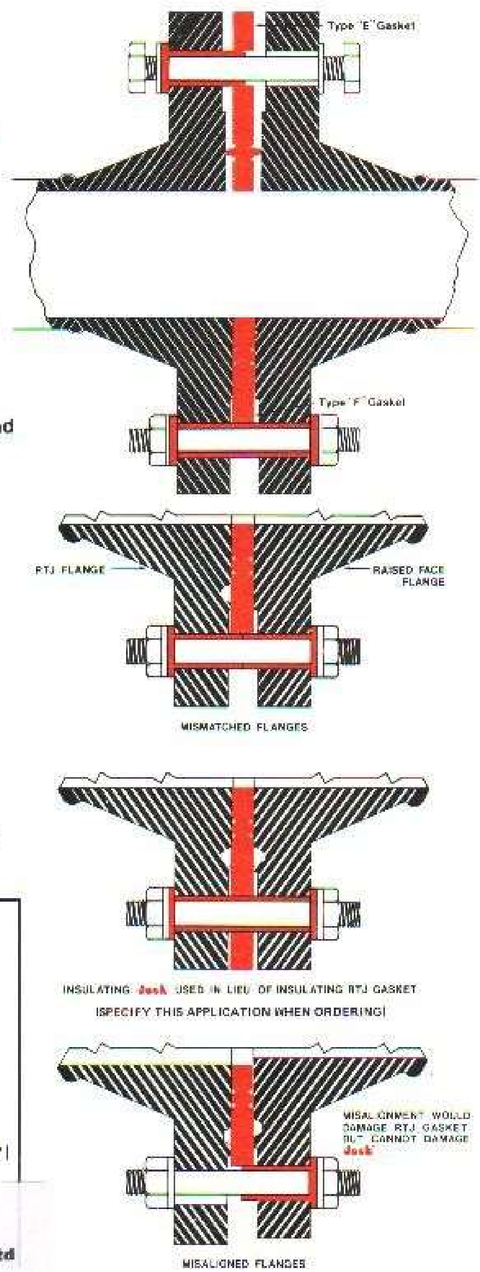
Jock™ O-RING GASKETS

BEFORE: The flange face contacts the crown of the elastomer seal ring. As the bolts are tightened the flange face deforms the seal crown into the molded voids.

AFTER: The flange faces are in complete contact with the seal retainer, thus encapsulating the seal elements in conjunction with the retainer grooves. The elastomer, because of it's resiliency and pressure from the line fluid, attempts to return to it's original shape and effects a positive o-ring type seal.

PROBLEMS SOLVED.............

- Fewer Service Calls due to leaking and "shorting" flanges.
- Positive Sealing through a wide range of fluctuating temperatures.
- Maintenance Versatility and Positive Sealing in difficult situations. (see examples)
- Longest Fire Life of any insulating gasket.
- Positive Seals and Zero Environmental Leakage.



HOW?

TO ORDER FLANGE INSULATION KIT PLEASE INDICATE THE FOLLOWING:

1. Quantity
2. Pipe Size (Nominal)
3. Pressure Rating (ANSI,DIN,API)
4. Gasket Type
5. Retainer Material
6. Sealing Element
7. Single or Double Washer Sets (SW or DW)
8. Sleeve Material

Distributed by
SAVCOR ART Pty Ltd
Lvl 13/132 Arthur St, Nth Sydney NSW 2060
Phone : 02 9025 2000

Transport for NSW

T HR EL 12002 GU

Guide

Electrolysis from Stray DC Current

Version 1.0
Issued Date: 01 May 2014
Effective Date: 01 May 2014

Preface

The Asset Standards Authority (ASA) develops, controls, maintains and publishes standards and documentation for transport assets for New South Wales, using expertise from the engineering functions of the ASA and industry.

ASA publications comprise of network and asset standards for NSW Rail Assets and include RailCorp engineering standards that were previously managed by RailCorp until July 2013.

This document supersedes RailCorp standard EP 12 30 00 01 SP *Electrolysis from Stray DC Current*, Version 3.0. The changes to previous content include:

- updates to reflect organisational changes and resulting changes in responsibilities
- minor amendments and clarification to content
- conversion of the standard to ASA numbering, format and style

Table of contents

1. Purpose

This document provides general information on electrolysis caused by stray dc currents. It explains where stray dc currents are originated from and discusses their potential effects. This document also offers techniques to minimise stray dc currents to mitigate possible electrolysis.

This guide is prepared for and applicable to NSW 1500 V dc electrified railway network.

2. Electrolysis

2.1 Description

Electrolysis is an electro-chemical reaction involving an electrolyte and metals which are carrying a dc current. It results in the corrosion of the metal which is carrying the current at the point where the current leaves the metal and enters the electrolyte.

In the case of stray dc traction currents, the electrolyte is the moist earth while the metals are the rails and buried metallic services such as pipes and the sheathing on power and communication cables. The buried services in the context of electrolysis are usually referred to as 'structures' but should not be confused with overhead wiring structures. The buried 'structure' does not necessarily have to be underground - it just has to connect to earth at two points. However, note that electrolysis only occurs in the ground.

Whether or not a buried structure is likely to be damaged by stray dc currents is determined by the correlation of the structure to rail and the structure-to-earth potentials. If the potential of structure-to-earth is positive, corrosion is likely; if it is negative, the structure receives protection from corrosion because of the stray dc currents.

As an example, the corrosion rate of steel is 9 kilogram per ampere year.

2.2 Legislative requirements

The NSW Department of Trade and Investment, Regional Infrastructure and Services (NSW Trade & Investment) is responsible for administering the *Electricity Supply (Corrosion Protection) Regulation 2008*, made under the *NSW Electricity Supply Act 1995*. This regulation requires the approval and registration of all cathodic protection systems (CPS) including both sacrificial (above 150 mA output) and impressed CPS, drainage bonds (DBs) and transformer assisted drainage bonds (TRADs). The administration is done in conjunction with the NSW Electrolysis Technical Committee (NSWETC).

The NSWETC meets monthly to program testing of both new and existing cathodic protection systems and to recommend approval of CPS. The NSWETC consists of representatives of NSW utilities and includes electricity, gas, water, telecommunications, pipeline, light and heavy rail and other allied/interested parties. Since its inception in 1932, the NSWETC has developed and refined specialised equipment and technical procedures for both CPS testing and investigating problems on members' assets arising from the operation of CPS and stray traction current.

It should be noted that the NSWETC is not a legal entity and does not have a registered office.

3. Stray dc current

The 1500 V dc electrified traction system consists of an overhead wiring system supplied by traction substations spaced every 5 km to 15 km along the tracks.

The current required to operate the train traction motors is received by the train pantograph from the contact wire, and then it returns to the traction substations via the wheels of the train and the unearthed track system. The overhead wiring is positive with respect to the rails.

Ideally, all current should return through the rails, but since the rails 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 leaked current is called 'stray current' or 'leakage current'.

Stray dc currents leave the rails far from the substation where there is a relatively low resistance to earth. The currents then use the path of lowest resistance to return to the substation. This usually involves entering a buried structure and then passing from that structure to the ground at some point closer to the substation. It then passes back to the rails at another point of relatively low resistance to earth and completes the circuit to the substation negative.

The return traction current flowing in the rails causes a longitudinal voltage drop along the length of the rails. Although the rails are nominally isolated from earth, there is inevitably a distributed leakage resistance causing a varying potential difference with respect to earth. This potential difference is negative near the traction substations and positive between substations. The resulting potential difference is generally 10 V to 70 V, which is not dangerous.

Regenerative braking fitted to newer trains causes the trains to act as mobile substations causing the rail potentials to be more variable than the simple case described above. In the simple model illustrated in Figure 1, substation earth is always positive to rail; but this is no longer always true.

It is neither practical nor desirable to completely insulate the rails from earth. Some amount of leakage current is acceptable to ensure that the voltage between rail and earth does not become dangerous. Another limiting factor in the rail to earth resistance is the signalling system which requires the rail to earth leakage resistance to be a minimum value of 2 Ω rail-to-rail per kilometre of rail. Thus the minimum allowable value is 1 Ω rail-to-earth per kilometre of rail. A typical track would usually have a value of approximately 8 Ω to earth for one kilometre of rail and a very well ballasted track would have a resistance of over 50 Ω to earth for one kilometre of rail.

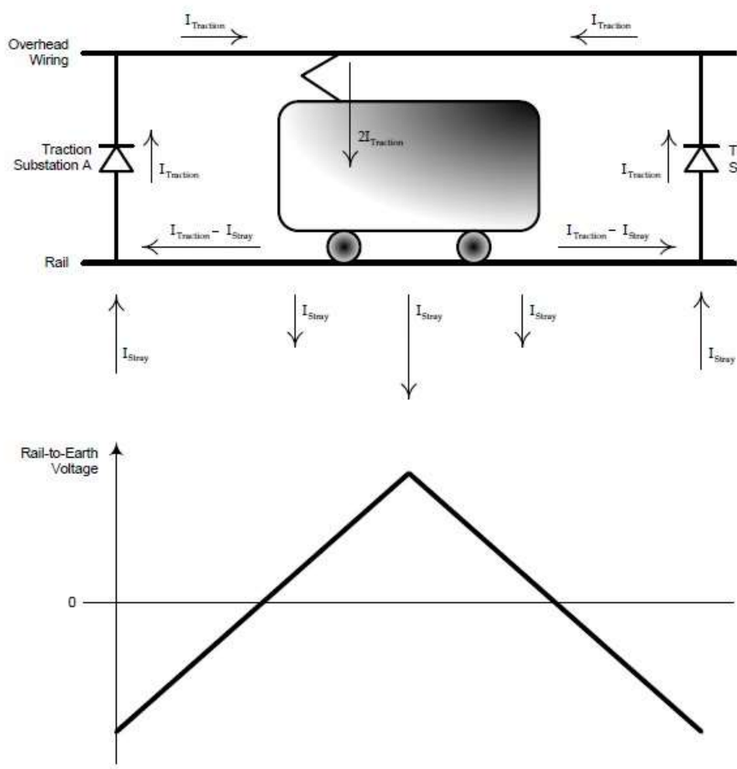


Figure 1: DC traction currents distribution and rail-to-earth voltage under uniform conditions

4. Effects and hazards

The most common stray dc currents paths in railway environment and the potential hazards and effects are discussed in this section.

4.1 Continuous structures

Continuous structures such as metallic fences and troughs provide conductive paths for stray dc currents because they are close to the tracks for long distances and are connected to earth at many points through which they may pick up and drop off stray dc currents.

Overhead earth wires erected for long distances over high voltage transmission lines to protect them against lightning are earthed at each pole and also connected to the substation earth mat, i.e. a very good connection to earth. These wires may also pick up and drop off stray dc currents along their route.

In addition to transfer of hazard (i.e. dc voltage), the buried parts of these structures are prone to corrosion at the drop off points – fence bases, toughing support columns and earth electrodes at the bottom of poles.

For further information refer to EP 12 10 00 21 SP *Low Voltage Installations Earthing*.

4.2 Overhead wiring structures

The OHW structure footing has a resistance to earth. A survey of structures has shown that these values of resistance to earth vary from 1.5 Ohms to 280 Ohms. Where an OHW structure is spark-gapped to rail and the spark gap operates (becomes short-circuited) a conductive path for stray dc currents is created.

If the spark gap is not replaced in a timely manner, the OHW structure base will corrode compromising its structural strength.

For further information refer to EP 12 20 00 01 SP *Bonding of Overhead Wiring Structures to Rail*.

4.3 MEN systems

The local distribution network service provider's (DNSP) low voltage supplies commonly use a multiple earthed neutral (MEN) system for earthing purposes. The neutral conductor – which is connected to earth at multiple points – is reticulated throughout the areas through which the RailCorp network operates. It provides a pick-up and drop-off facility for stray DC currents resulting in corrosion of the earth electrodes at the drop-off points.

A power supply with MEN system is only permissible if the installation and its earthing electrodes are at a reasonable distance from the electrified rail or any metallic element which may be connected to rail. This provision is also to ensure the safety of the consumers connected to the low voltage network by minimising the possibility of stray DC current flowing into the low voltage network.

For further information refer to EP 12 10 00 21 SP *Low Voltage Installations Earthing*.

4.4 Concrete bridges

The use of reinforced or pre-stressed concrete bridges raises special concerns when used for dc electrified railway networks. If the reinforcing bars or stressing wires are not insulated from rails then these will carry traction current. Even if they are insulated, concrete is not a good insulator and there could be some stray current in the bars/wires. The length of the concrete bridge structures increases the possibility to be affected by stray dc currents.

Since the steelwork is necessary for the strength of concrete bridges, it is vital that corrosion does not occur.

Over the years, numerous methods have been tried to minimise the corrosion of bridge steelwork. A few are listed below:

- insulating membranes have been installed in the concrete between the rails and the reinforcement. But this type of installation is prone to damage during construction and cannot be repaired after the bridge is built
- all steelwork have been bonded together and the current flow has been monitored to ensure there is minimal leakage. If leakage is found to be excessive, then drainage bonds can be installed
- some major pre-stressed concrete bridges such as the ones at Rushcutters Bay and Woolloomooloo viaducts have been successfully insulated by an insulating layer of epoxy grout between the roadbed concrete and the structural concrete

4.5 Earthed rail locations

The RailCorp network traction system is not deliberately connected to earth, although earthing on only one side is allowed; one side only to avoid creation of a complete electric circuit.

When the voltage between rail and earth becomes large, rails are automatically connected to earth via rail-earth contactors (REC) to mitigate the hazard. The connection has to be removed after safe voltage levels have been reinstated.

Earthed rails, obviously, provide direct path for rail currents to enter earth – this is no longer stray dc current but the actual traction return current – and have to be avoided unless necessary.

However, some situations require that the rails be earthed for safety reasons. Examples are in coal and wheat loaders, where sparks caused by a voltage between rails and earth can be catastrophic.

For further information refer to EP 12 10 00 13 SP *1500 V Traction System Earthing*.

5. Minimisation techniques

The problem of minimising electrolysis is closely related to the problem of earthing bonding of metallic structures to prevent electric shock to people. The solutions problems have to be a compromise since the 'best' solution for one situation res problems for the other one.

The techniques discussed in this section are as follows:

- maintaining high resistance between rails (and negative connections
- minimising voltage drop between traction substations
- isolation of services, installations and structures from dc elec
- breaking continuity in continuous structures

The above minimisation techniques are recommended for and near 1500 V dc track. All associated mandatory documents.

5.1 High resistance to earth

Ensure the rails and associated negative cor
To achieve a high resistance to earth, ensur

- the rails are clear of dirt and m through stations
- steel sleepers are not us because track circuiting
- non-electrified lines and that these join
- spark gaps ha
- in tunnels, rails and
- at s tr
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T HR EL 12002 GU
Electrolysis from Stray DC Current
Version 1.0
Effective Date: 01 May 2014

5.2 Voltage drop minimisation

Ensure the voltage drop along the rails is minimised; in other words, the electrical resista
the traction return circuit is minimised.

To minimise the voltage drop:

- use as many running rails as possible for traction return
- install tie-in bonds to share the current between tracks
- ensure all rail bonds and impedance bonds are correctly installed
- minimise substation spacing
- ensure substation voltages are equalised

Adjacent substations should have balanced output voltage traction return current to a minimum resulting in lower volt the voltage available to drive a stray dc current from t substation will be minimised.

5.3 Isolation

The following isolation methods can be utilised

- keep metallic services away from th up appreciable dc leakage cur electrified lines
- use isolating transformers ensuring that no neutral
- provide isolating join gas pipes servicin
- ensure that m near 1500 services
- ensur fen
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5.4 Breaking continuity

For continuous structures as described in section 4.1, it is recommended to:

- install insulating panels every 500 m of metallic fences along the tracks
- install insulating sections every 500 m of metallic troughs along the tracks. Care must be taken to ensure that metallic lids of the troughs do not bridge the insulated sections
- ensure that there are no long lengths of metallic water/gas/air pipes within the railway corridor, in particular in car sheds
- ensure that RailCorp network high voltage cable screens are not continuous between substations
- divide underground metallic structures into short lengths using insulating joints
- do not use concrete poles in the railway corridor and near 1500 V dc lines. All local DNSPs have been advised not to use concrete poles near 1500 V dc tracks, especially if overhead earth wire or neutral wire is fitted

5.5 Use of protection systems

Corrosion protection systems methods that can be used to minimise the effect of electrolysis are:

- cathodic protection (CP) systems
- drainage bonds

In CP systems the metal that is to be preserved is made negative to earth and thus avoiding corrosion. However, with relatively large voltages caused by stray currents, CP is not entirely effective and hence railway drainage bonds may be useful.

A drainage bond relies on a deliberate metallic connection of the structure to rails in order that the stray currents return to the rail without entering the earth. See Figure 2 for a typical drainage bond arrangement.

The drained structure – the structure to be protected – becomes negative to earth and therefore attracts current from adjacent structures. Excessive drainage from one structure may cause hazard to other structures in vicinity of the protected structure, particularly when crossing each other. Thus, drainage bonds are fitted with resistance to limit the current returning to rails from the protected underground structure to avoid excessive drainage.

For example, in the case of steel structures, it is preferable to keep the voltage to earth between −2000 mV and −850 mV. At more negative voltages, damages such as hydrogen embrittlement or disbonding of insulation may take place. The common method used to determine the voltage affecting the structure is by using $Cu/CuSO_4$ half-cell making repeatable contact with earth.

The corrosion effect on the underground structures very largely depends whether the structures are bare or insulated/coated. Although insulation of metallic structures, if perfectly applied and maintained, can provide complete protection against galvanic corrosion, defects in insulation are unavoidable. The consequence of a defective insulation is that stray dc currents may be concentrated in a small defected area and accelerate the rate of corrosion at that point. Hence, insulation of metallic structures from their environment is usually supplemented with the CP systems. However, full protection against stray dc currents cannot be obtained because CP system voltages are generally lower than the traction voltages involved.

For more information refer to:

- AS 2832 *Cathodic protection of metals*
- guide for measurement of interference caused by cathodic protection and railway drainage systems prepared by the NSWETC

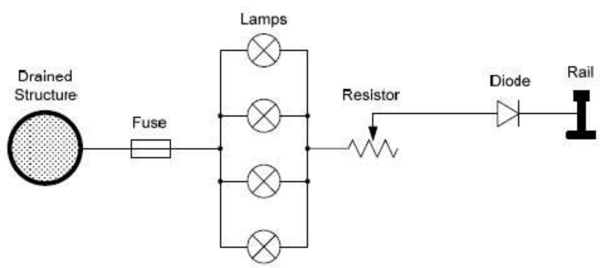

Figure 2: Typical electrolysis drainage bond panel

Below are some typical values for various components forming a drainage bond:

Table 1 – Typical values for components of drainage bonds

Component	Value
Fuse	25 A
Lamps	32 V, 250 W
Resistor	0.30 Ω, taps at 0.22, 0.26, 0.30 Ω Usually connected at 0.26 Ω
Diode	40HFR120 (Supplied by RS Components)
Conductance Bond	1.5 S, 4 V (I = 6 A)